Appendix A

Water Quality Data Report

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FINAL REPORT
REVISION 1.0

APPENDIX A
WATER QUALITY DATA REPORT

Prepared for

U.S. Forest Service

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This Water Quality Data Report (WQDR) is Appendix A of the Data Summary Report (DSR) prepared for the United States Forest Service (USFS) for abandoned mine sites located within the Illinois Gulch watershed, located east of Breckenridge, Colorado (Figure 1).

Illinois Gulch is contained within Colorado Water Body Identification segment COUCBL12. This segment is not supporting the Aquatic Life Use-based water quality standards for dissolved zinc and cadmium. Total Maximum Daily Loads (TMDLS) for dissolved zinc and dissolved cadmium were approved in December 2009 and July 2011 respectively (Colorado Department of Public Health and Environment [CDPHE] 2009b; 2011). This WQDR serves to summarize water quality data collected during high and low flow surface water sampling events conducted from 2012 through 2014. Results from future sampling events may be appended to the DSR in similar fashion.

There are two main tributaries that contribute mine-impacted surface water to the lower reach of Illinois Gulch: Iron Springs Gulch and Little Mountain Springs Gulch. Surface water flows to Iron Springs Gulch originate from the two Willard Adits and beaver pond located north of Boreas Pass Road, and are encircled by the switchback located east of Bright Hope Lane. Iron Springs Gulch flows into Illinois Gulch approximately 1,200 feet upstream of the Breckenridge Ice Rink facility. Little Mountain Springs Gulch originates on the south side of Boreas Pass Road below Little Mountain, and flows under the road west of Bright Hope Lane and into Iron Springs Gulch just above the confluence of Iron Springs Gulch and Illinois Gulch.

USFS and cooperating agencies will utilize the DSR to make decisions on further characterization of mine sites that are impacting Illinois Gulch. All work was conducted in accordance with the CDPHE Sampling and Analysis Plans (SAPs) prepared in 2012 and 2013.

2.1 INITIAL ROUTINE WATER QUALITY MONITORING

The Blue River Segment 12 (Illinois Gulch) has been on the State's 303(d) list of water quality impaired water bodies for nonattainment of water quality standards for dissolved zinc since 2004, when it was given a high priority, and in 2010 was identified on the 303(d) list for nonattainment of water quality standards for dissolved cadmium. Excess dissolved zinc originating from historic mining activity impairs the Aquatic Life Cold 1 classification for Segment 12.

The Water Quality Control Division (WQCD) has a routine monitoring site (IG-01) on Illinois Gulch near the Breckenridge Ice Rink. This monitoring site provided water quality data from 2001 to 2007. During April 2006, EPA responded to a reported problem in the vicinity of Illinois Gulch when the Puzzle Mine discharged a slug of orange water which flowed through Iron Springs Gulch, into Illinois Gulch, and through Breckenridge. Some follow-on monitoring was conducted in Illinois Gulch near the mine and in the Blue River; however, these data were not used in calculating the TMDL as hardness was not reported and total metals (not dissolved) were reported. The slug discharge was likely caused by an ice dam breaking loose within the adit.

2.2 TOTAL MAXIMUM DAILY LOAD ASSESSMENT WATER QUALITY STUDIES

Following the routine monitoring, the WQCD conducted four synoptic sampling events; two in 2008 and two in 2010. Six sites were sampled located upstream from the Willard Mine (Illinois Gulch at Illinois Gulch Road), the Willard Mine seepage, Iron Springs Gulch upstream from the confluence with Illinois Gulch, Illinois Gulch upstream of the confluence with Iron Springs Gulch, Illinois Gulch downstream of the confluence with Iron Springs Gulch, and Illinois Gulch at the Breckenridge Ice Rink (Figure 1). These data were utilized in the development of the total maximum daily load (TMDL).

TMDLs for dissolved zinc and dissolved cadmium were submitted by WQCD and approved by USEPA in December 2009 and May 2011 respectively. The TMDL calculated load reductions required to attain chronic dissolved zinc and cadmium standards. The reductions were calculated for high flow and low flow conditions for Illinois Gulch below the confluence with Iron Springs Gulch.

- During the development of the TMDLs four zinc results were recorded in 2008 on Illinois Gulch above the Iron Springs Gulch confluence. A mean hardness of 88.5 mg/L was used to calculate a chronic zinc Aquatic Life Use-based standard of 112.10 µg/L, which when compared to 98.2 µg/L (the 85 % of zinc) shows attainment. Of these four sampling events, there were no exceedances of the zinc acute aquatic life standard. Six cadmium results were recorded on Illinois Gulch above the Iron Springs Gulch confluence between 2008 and 2010. All samples resulted in less than detectable levels of cadmium and were in attainment of chronic and acute Aquatic Life Use-based standards. While the portion of Illinois Gulch above the confluence with Iron Springs Gulch is attaining water quality standards, zinc concentrations are elevated (equal to about 87% of the chronic standard) for this portion. Abandoned mine waste rock piles in close proximity to Illinois Gulch have been observed in this portion.

Based on the TMDL assessments, water quality in Illinois Gulch above the Iron Springs Gulch (and influence of the Puzzle Mine) was determined to be in attainment of assigned standards, whereas water quality in Iron Springs Gulch (which includes flow from the Little Mountain seeps/springs) and in Illinois Gulch below its confluence with Iron Springs, has elevated zinc levels. Reports from CDPHE to the EPA summarizing the TMDL assessments and calculations from December 2009 and July 2011 are included in Attachment B.

2.3 CDPHE INVESTIGATIVE WATER QUALITY STUDIES

WQCD has a routine monitoring site (IG-01) on Illinois Gulch near the Breckenridge Ice Rink. This monitoring site provided water quality data from 2001 to 2007. In addition to routine monitoring, the WQCD conducted synoptic sampling events; two in 2008 and two in 2010. Following previous water quality investigations in Illinois Gulch, CDPHE has conducted expanded surface water quality sampling events to investigate sources for heavy metals loading. These efforts included seven separate surface water sample collection events conducted from 2012 to 2014 as summarized below in chronological order:

- In May 2012, CDPHE conducted an initial surface water sample collection during high flow conditions at sample points IG-01 through IG-16.
- In August 2012, CDPHE conducted a surface water sample collection during low flow conditions at the same surface water sample points with the exception of IG-03 and IG 13, which were not collected. Additionally, site IG-03-01 was added during this sample event.
- In June 2013, CDPHE conducted a surface water sample collection event during high flow conditions at sample points IG-01 through IG-16. A sample from site IG-03-01 was not collected during this sample event.
- In July 2013, CDPHE collected surface water samples at three new surface water sample points IG-17 through IG-19.
- In August 2013, CDPHE conducted a surface water sample collection event during low flow conditions at sample points IG-01 through IG-19. A sample from site IG-03-01 was not collected during this sample event.
- In July 2014, CDPHE conducted a surface water sample collection event during high flow conditions at sample points IG-01 through IG-19. Samples were also collected from four new locations associated with Laurium and Mountain Pride Mines, OP 01 to OP 04 (Opportunity Points, not shown on maps as GPS coordinates unavailable); however, a sample from site IG-03-01 was not collected during this sample event.
- In September 2014, CDPHE conducted a surface water sample collection event during low flow conditions at sample points IG-01 through IG-19, as well as at points OP 01 and OP 02, but not from OP 03, OP 04, or IG-03-01.

Results from these seven investigations are presented in Section 4.0.

This section provides an overview of the sampling activities for the seven surface water quality sampling events from 2012 to 2014. Sampling activities and results from prior efforts (i.e., WQCD TMDL assessments) are summarized in reports included in Attachment B (Techlaw 2014 and USEPA 2015).

The sampling locations varied between events, but in total there have been 25 different surface water sample locations in the Illinois Gulch sampling program as shown in Table 3-1. Figure 1 presents locations for 21 of the 25 locations (sample points OP-01 to OP-04 excepted as their coordinates were not reported or did not agree with written/photo documentation). Two field blanks and two field duplicates are collected during each sampling event for quality assurance/quality control (QA/QC). Samples are transported under chain-of-custody (COC) to the CDPHE Laboratory Services Division located in Denver, Colorado. Surface water samples are analyzed for the following analytes per the SAP (USFS 2014):

- Total Metals (Method 200.7/200.8)
- Dissolved Metals (Method 200.7/200.8)
- Total and Dissolved Mercury (Method 245.1)
- Alkalinity (Method 310.1)
- Hardness (Calculated - Method 200.7)
- Nutrients (Methods 350.1, 351.2, 353.2, and 365.1)
- Sulfate (Method 300.0)

Additionally, the following water quality parameters were measured in the field using a water quality field probe:

- Dissolved oxygen
- Temperature
- pH
- Conductivity

Table 3-1
Illinois Gulch Surface Water Quality Sample Locations

Illinois Gulch Sample Locations		
Site ID	**Site Description**	**Site Type**
IG-01	SW Corner Breckenridge Rink parking lot	River/Stream
IG-02	Illinois Gulch below Iron Springs Gulch Confluence.	River/Stream
IG-03	Illinois Gulch above Iron Springs Confluence	River/Stream
IG-3-1	Illinois Gulch above Iron Springs Gulch Confluence.	River-Stream
IG-04	Iron Springs Gulch below Little Mountain Confluence.	River/Stream
IG-05	Iron Springs Gulch above Little Mountain Confluence.	River/Stream
IG-06	Little Mountain above Iron Springs Gulch Confluence.	River/Stream
IG-07	Little Mountain Spring 2 – Spring above mine influence.	Adit/ mine feature
IG-08	Iron Mtn. seep/ Little Mountain Spring 1 - Seep discharge.	Adit/ mine feature
IG-09	Iron Springs Gulch below Bright Hope Road.	River/Stream
IG-10	Iron Springs Gulch below Willard Adit Discharge and Mine Dump Seepage Confluence.	River/Stream
IG-11	Iron Springs Mine Dump Seepage above Confluence with Willard Adit Discharge.	River/Stream
IG-12	Iron Springs Mine Dump Seep.	Adit/ mine feature
IG-13	Iron Springs Willard Adit Discharge. Puzzle Adit	Adit/ mine feature
IG-14	Illinois Gulch at Wildflower condos/ Illinois Gulch Rd	River/Stream
IG-15	Illinois Gulch reference site	River/Stream
IG-16	Puzzle Mine draining adit located 100 yards to the north of Puzzle Adit	Adit/ mine feature
IG-17	Outlet of beaver pond that is adjacent to waste rock piles	River/Stream
IG-18	Inlet of beaver pond that is adjacent to waste rock piles	River/Stream
IG-19	Unnamed stream next to Bright Hope Road	River/Stream
OP-1	Laurium Mine Adit discharge that is discharging from a four-inch PVC pipe protruding from an old mine shack that has been converted into a sauna	Adit/ mine feature
OP-2	Illinois Gulch upstream of IG-15 and Laurium mine site	River/Stream
OP-3	Illinois Gulch just downstream of Mountain Pride Mine tailings piles	River/Stream
OP-4	Illinois Gulch upstream of Mountain Pride Mine	River/Stream

This section of the report presents the analytical results for the seven surface water quality sampling events conducted in 2012, 2013, and 2014. A high flow and low flow event were completed each year. There are seven events because three new sampling locations were added in July of 2013 (after the June 2013 high flow event), IG-17, IG-18, and IG-19.

The discussion of the analytical results, dissolved concentrations of metals, flow rates, and metal loading calculations is divided by different segments of the Illinois Gulch stream system and mine features. The different stream segments and mine feature discharge areas described include:

- Illinois Gulch
- Iron Springs Gulch
- Little Mountain Spring Tributary, and
- Iron Springs Gulch Mine Features (adits, mine dump seep, beaver pond)

4.1 SURFACE WATER ANALYTICAL RESULTS

The surface water sample locations that were sampled during the seven 2012 to 2014 high and low flow sampling events are shown on Figures 1 and 2. Figures 3, 4, and 5 show the flow rates, pH, hardness, and metal concentrations for the high and low flow sampling events at each sampled point during the 2012, 2013, and 2014 events, respectively. Analytical results for surface water samples are presented on the benchmark tables included in Attachment A, and are also summarized on the in-text tables included in the subsequent sections below. Location-specific water quality criteria were calculated for each sampled location per event using correlations that take hardness into account. These values are referred to as benchmark values and are used for evaluating water quality attainment. CDPHE laboratory report spreadsheets downloaded from SCRIBE for the 2014 sampling events are included in Attachment D. As stated in Section 3, surface water samples were analyzed for total and dissolved metals, selected inorganic parameters, and measured for field parameters including dissolved oxygen, temperature, pH, and conductivity.

Surface water sample metals concentrations were compared to hardness adjusted benchmark levels from the basic standards and methodologies for surface water (CDPHE 2009a). The benchmark levels are shown on the benchmark tables included in Attachment A.

The surface water sample results for dissolved metals, flow rates, and metal loading rates for sample points associated with each mine site are discussed below. Metal loading rates for cadmium and zinc have been provided in this data summary. Zinc and cadmium have been selected for the metal loading rate calculations because Illinois Gulch was identified on the state of Colorado's 303(d) list for nonattainment of water quality standards for dissolved cadmium and zinc. TMDLs for zinc and cadmium were approved by the United States Environmental Protection Agency (USEPA) in 2010 and 2011, respectively (CDPHE 2009b; 2011).

Bar charts for several parameters are provided in Attachment D. The bar charts summarize the following data for each surface water sample location: flow rate, pH, dissolved cadmium and zinc concentrations, and calculated cadmium and zinc loading rates.

4.1.1 Illinois Gulch Main Stem Sample Results

Sample locations in the main stem of Illinois Gulch include IG-15, IG-14, IG-03, IG-03-01, IG-02, and IG-01 (Figure 1). Sample point IG-15 is a reference sample point representing Illinois Gulch water quality upstream from the Iron Springs mining feature influence. Sample points IG-02 and IG-01 are located below the confluence of Iron Springs and Illinois Gulch. Table 4-1a shows flow rates and concentrations of metals detected along the Illinois Gulch main stem. Loading rates for cadmium and zinc are shown in Table 4-1b.

Illinois Gulch Main Stem Sample Locations		
Site ID	Site Description	Site Type
IG-01	SW Corner Breckenridge Rink parking lot	River/Stream
IG-02	Illinois Gulch below Iron Springs Gulch Confluence	River/Stream
IG-03	Illinois Gulch above Iron Springs Confluence	River/Stream
IG-3-1	Illinois Gulch above Iron Springs Gulch Confluence	River-Stream
IG-14	Illinois Gulch at Wildflower condos/ Illinois Gulch Road	River/Stream
IG-15	Illinois Gulch upstream reference site	River/Stream

Flow Rates

The flow rates from upstream sample point IG-15 ranged from 2.2 cubic feet per second (CFS) in June 2013 during high-flow conditions to 0.04 CFS in August 2012 during low-flow conditions.

The flow rates from downstream sample point IG-01 ranged from 5.89 CFS in June 2013 during high-flow conditions to 0.16 CFS in August 2012 during low-flow conditions.

Flow rates generally increased from upstream to downstream in Illinois Gulch with the exception of location IG-03, which is located immediately above the confluence with Iron Springs Gulch. Flows during both high and low-flow periods typically decreased between location IG-14 and IG-03. Flow typically increased below IG-03 to IG-02 and IG-01.

Dissolved Metal Concentrations

Cadmium and zinc were detected at concentrations exceeding benchmark levels at sample points collected within Illinois Gulch, including at upstream location IG-15. Copper concentrations also exceeded the benchmark in June 2013 the lower reach of the stream, below Iron Springs Gulch. The highest metal concentrations for the Illinois Gulch main stem were detected in the samples collected at IG-02 and IG-01, which are both located downstream from the confluence with Iron Springs Gulch.

Dissolved cadmium and zinc exceed benchmark screening levels at upstream site IG-15, however copper, iron and manganese were detected at concentrations below the benchmark screening levels. Dissolved metal concentrations in Illinois Gulch increase significantly for several metals at sample location IG-02, located immediately below the confluence with Iron Springs Gulch. Zinc concentrations increased from 180 µg/L in IG-15 to 430 µg/L at IG-01 during the August, 2013 low-flow sampling event. Cadmium, copper, and iron dissolved concentrations also increased at IG-02 and IG-01. Dissolved iron exceeded the benchmark screening level at location IG-01 in June 2013.

"Opportunity samples" were collected from three upstream areas along Illinois Gulch and one adit above Illinois Gulch in July and two samples in September of 2014, however the GPS coordinates did not match well with the written narrative and photo documentation, and so the data was not posted on the maps or tables in this report. However, the dissolved metals concentration results for zinc are discussed in the following paragraph. The water quality results are listed with the other surface water samples on the benchmark screening level tables in Attachment A. Specifically, Attachment A-6 for July 2, 2014 (all four samples), and Attachment A-7 for September 18, 2014 (OP-01 and OP-02).

The four sample location names, from upstream to downstream are: OP-04, OP-03, OP-02, and OP-01. Sample location OP-04 is reportedly located upstream of Mountain Pride Mine, which would place this location upstream of known mine sites in Illinois Gulch. Mine claims are mapped above this location on USGS topographic maps, but no mine openings are identified. Water quality data collected at OP-04 had dissolved zinc detections of 10.2 µg/l, suggesting minimal natural or anthropogenic impacts in this area. Zinc concentrations increased to 68 µg/l downstream at OP-03 (downstream of Mountain Pride mine tailings pile), 194 µg/l at OP-02 (upstream of Larium Mine and IG-15), and 540 µg/l at OP-01 (the Larium Mine adit discharge from a mine shack). Routine monitoring location IG-15 is evidently located downstream of OP-04. The dissolved zinc concentration in the sample from IG-15 in July 2014 was 169 µg/l.

Metal Loading Rates

Metal loading rates increase within Illinois Gulch below the confluence with Iron Springs Gulch at sample points IG-02 and IG-01. The highest calculated loading rates for zinc and cadmium along the main stem of Illinois Gulch are at locations IG-01 and IG-02, below the confluence from Iron Springs Gulch. Loading rates were highest for zinc and cadmium in June 2013. The zinc loading rates at IG-01 and IG-02 were 13 and 9.9 pounds per day (lbs/d), respectively. The cadmium loading rates at IG-01 and IG-02 were 0.07 and 0.054 lbs/d, respectively for June 2013.

Zinc and cadmium metal loading rates are shown in Table 4-1b below and the bar charts in Attachment D. Metal loading charts for zinc and cadmium oriented along the stream profile for each sampling event are also provided in the Charts section.

Table 4-1a
Illinois Gulch Main Stem Hardness, pH, Flow Rate, and Dissolved Metal Results

Sample Location	Sample ID	Sample Date	Hardness (mg/L)	pH	Flow Rate (CFS)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Fe (T) (µg/L)	Pb (µg/L)	Mn (µg/L)	Ni (µg/L)	U (µg/L)	Zn (µg/L)
Illinois Gulch upstream from Iron Springs Mining Influence	IG-15	05/31/12	78	7.28	0.49	0.16	***0.9***	< 5	36	0.39	< 2	< 2	0.35	***170***
		08/22/12	96	7.9	0.04	0.16	1.5	< 5	110	0.5	< 2	< 2	0.73	13
		06/05/13	63	7.49	2.21	0.15	***1.2***	< 4	50	1.3	< 2	< 1	0.21	***250***
		08/28/13	78	7.88	0.11	0.17	***0.83***	< 4	6.9	1.2	< 2	< 1	0.25	***180***
		07/02/14	52	8.05	0.608	<0.5	**0.806**	1.25	<100	**1.87**	<2	<0.5		**169**
		09/18/14	107	7.7	0.1378	<0.5	**1.54**	0.821	<100	1.25	2.42	<0.5		**361**
Illinois Gulch at Illinois Gulch Road	IG-14	05/31/12	84	7.57	1.27	0.18	***0.39***	< 5	460	< 0.15	5	< 2	0.28	79
		08/22/12	91	7.94	0.14	0.23	0.37	< 5	30	< 0.15	17	< 2	0.3	100
		06/05/13	77	7.68	5.63	0.23	***0.4***	< 4	420	0.38	5	< 1	0.24	***100***
		08/28/13	95	7.93	0.93	0.22	0.36	< 4	76	0.21	16	< 1	0.33	77
		07/02/14	69	7.50	3.009	<0.5	**0.449**	0.866	<100	0.262	5.31	<0.5		**94.2**
		09/18/14	95	7.85	0.6118	<0.5	**0.474**	<0.5	<100	0.132	16.5	<0.5		106
Illinois Gulch above Iron Springs Gulch Confluence	IG-3-1	08/22/12	96	8.14	0.18	0.33	***0.66***	< 5	9	0.18	3	< 2	0.32	110
Illinois Gulch above Iron Springs Gulch Confluence	IG-03	05/31/12	86	6.32	1.18	0.25	***0.66***	< 5	36	< 0.15	3	< 2	0.29	77
		06/05/13	82	7.787	4.92	0.27	***0.71***	< 4	310	0.51	3	< 1	0.24	***120***
		08/28/13	98	7.53	0.28	0.28	***0.65***	4.1	34	0.37	< 2	< 1	0.31	86
Illinois Gulch below Iron Springs Gulch Confluence	IG-02	05/31/12	97	8.31	1.04	0.31	1.9	< 5	490	0.38	170	< 2	0.28	***390***
		08/22/12	120	7.06	0.33	0.4	***2.3***	< 5	420	0.21	380	3	0.26	***740***
		06/05/13	84	7.61	5.23	0.26	***1.9***	***8.1***	690	0.91	87	1.7	0.22	***350***
		08/28/13	120	6.26	0.87	0.34	***1.6***	< 4	350	0.34	230	1.1	0.28	***430***
		07/02/14	87	7.60	5.246	<0.5	**1.99**	5.16	406	0.359	147	1.06		**405**
		09/18/14	133	7.43	0.5984	<0.5	**2.87**	3.06	950	0.407	398	2.2		**798**

Table 4-1a
Illinois Gulch Main Stem Hardness, pH, Flow Rate, and Dissolved Metal Results

Sample Location	Sample ID	Sample Date	Hardness (mg/L)	pH	Flow Rate (CFS)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Fe (T) (µg/L)	Pb (µg/L)	Mn (µg/L)	Ni (µg/L)	U (µg/L)	Zn (µg/L)
Illinois Gulch at Ice Arena	IG-01	05/31/12	98	7.08	1.10	0.32	***1.7***	< 5	410	0.54	160	< 2	0.33	***340***
		08/22/12	120	7.67	0.16	0.27	***1.6***	< 5	110	< 0.15	260	< 2	0.28	***480***
		06/05/13	89	7.4	5.89	0.25	***2.2***	***10***	***1100***	1.3	110	2.1	0.27	***400***
		08/28/13	130	8.07	0.58	0.28	***1.5***	4	240	0.33	230	1	0.29	***430***
		07/02/14	86	7.77	3.357	<0.5	1.74	4.32	296	0.314	120	1.09		357
		09/18/14	132	7.94	0.4845	<0.5	2.13	2.3	296	0.559	327	1.33		693

Notes:
< = Indicates that concentrations were reported below detection limits.
Bold and shaded values indicate concentrations that exceed benchmark screening levels.

µg/L = microgram per liter
As = Dissolved Arsenic
Cd = Dissolved Cadmium
CFS = cubic feet per second
Cu = Dissolved Copper
Fe (T) = Total Iron
ID = Identification
mg/L = milligram per liter
Mn = Dissolved Manganese
Pb = Dissolved Lead
U= Dissolved Uranium
Zn = Dissolved Zinc
Ni = Dissolved Nickel

Table 4-1b
Illinois Gulch Main Stem Dissolved Zinc and Cadmium Loading Rates

Sample ID	Sample Date	Flow Rate (CFS)	Zn Loading (lbs/d)	Cd Loading (lbs/d)
IG-15	05/31/12	0.49	0.451	0.0024
	08/22/12	0.04	0.003	0.0003
	06/05/13	2.21	2.982	0.0143
	08/28/13	0.11	0.106	0.0005
	07/02/14	0.61	0.554	0.0026
	09/18/14	0.14	0.268	0.0011
IG-14	05/31/12	1.27	0.54	0.0027
	08/22/12	0.14	0.08	0.00028
	06/05/13	5.63	3	0.01
	08/28/13	0.93	0.39	0.0018
	07/02/14	3.01	1.53	0.01
	09/18/14	0.61	0.35	0.002
IG-3-1	08/22/12	0.18	0.11	0.00064
IG-03	05/31/12	1.18	0.49	0.0042
	06/05/13	4.92	3.2	0.019
	08/28/13	0.28	0.13	0.0010
	07/02/14	2.32	1.15	0.01
	09/18/14	0.09	0.06	0.0005
IG-02	05/31/12	1.04	2.2	0.011
	08/22/12	0.33	1.3	0.0041
	06/05/13	5.23	9.9	0.054
	08/28/13	0.87	2.0	0.0075
	07/02/14	5.25	11.46	0.06
	09/18/14	0.60	2.58	0.01
IG-01	05/31/12	1.10	2.0	0.010
	08/22/12	0.16	0.41	0.0014
	06/05/13	5.89	13	0.07
	08/28/13	0.58	1.3	0.0047
	07/02/14	3.36	6.47	0.03
	09/18/14	0.48	1.81	0.01

Notes:
Cd = Dissolved Cadmium
CFS = cubic feet per second
ID = Identification
lbs/d = pounds per day
Zn = Dissolved Zinc

4.1.2 Iron Springs Gulch Results

Sample locations at Iron Springs Gulch include IG-11, IG-10, IG-09, IG-05, and IG-04. This section discusses the non-mine feature locations that are within Iron Springs Gulch proper, i.e. not adits and other sources located above the Willard Pile or "mine dump". These other sample locations within Iron Springs Gulch are discussed under Iron Springs Gulch Mine Features (IG-13, IG-12, IG-16, IG-17, IG-18, and IG-19). Sample points IG-10 and IG-11 are collected within a wetland area below the draining Willard Mine adit area. A large mine dump, consisting of waste rock piles is present in the middle of the area, and there are residences located immediately north of one draining adit and the mine dump. Table 4-2a shows flow rates and concentrations of metals detected along Iron Springs Gulch. Loading rates for cadmium and zinc are shown in Table 4-2b.

Iron Springs Gulch Sample Locations		
Site ID	**Site Description**	**Site Type**
IG-04	Iron Springs Gulch below Little Mountain Confluence.	River/Stream
IG-05	Iron Springs Gulch above Little Mountain Confluence.	River/Stream
IG-09	Iron Springs Gulch below Bright Hope Road.	River/Stream
IG-10	Iron Springs Gulch below Willard Adit Discharge and Mine Dump Seepage Confluence.	River/Stream
IG-11	Iron Springs Mine Dump Seepage above Confluence with Willard Adit Discharge.	River/Stream

Flow Rates

The flow rates from upstream sample point IG-11 was measured at 0.0052 CFS in May 2012 during high-flow conditions and was 0.011CFS in August 2013 during low-flow conditions. Flow rates were not measured during the August 2012, June 2013, or 2014 sampling events. Flow rates increase immediately downstream, where the flow from Willard Adit 2 enters Iron Springs Gulch.

The flow rates from downstream sample point IG-04 ranged from 0.65 CFS in June 2013 during high-flow conditions to 0.21CFS in August 2012 during low-flow conditions.

Dissolved Metal Concentrations

Cadmium, copper, iron, lead, manganese, and zinc were detected at concentrations exceeding benchmark levels. The highest metal concentrations and lowest pH values were detected in the samples collected from the Iron Springs Mine Dump seepage above the confluence with the Willard Adit discharge at sample points IG-11 and IG-10. These locations had acidic pH values ranging from 2.17 to 4.53 and elevated concentrations of cadmium, copper, total iron, lead, manganese, and zinc.

Metal Loading Rates

Metal loading rates increase within Iron Springs Gulch below the Willard Adit discharge and mine dump seepage confluence at sample point IG-10. Metal loading rates decrease slightly downstream between locations IG-10 to IG-06, to IG-05, and then increase at location IG-04 which is below the confluence with Little Mountain Spring tributary. The highest cadmium and zinc loading rates of *all* the sample locations in the Illinois Gulch watershed were calculated for location IG-10, and were 15 and 0.071 lbs/day in June 2013.

Zinc and cadmium metal loading rates are shown in Table 4-2b below and the bar charts in Attachment D. Metal loading charts for zinc and cadmium oriented along the stream profile for each sampling event are also provided in the Charts section.

Table 4-2a
Iron Springs Gulch Hardness, pH, Flow Rate, and Dissolved Metal Results

Sample Location	Sample ID	Sample Date	Hardness (mg/L)	pH	Flow Rate (CFS)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Fe (T) (µg/L)	Pb (µg/L)	Mn (µg/L)	Ni (µg/L)	U (µg/L)	Zn (µg/L)
Iron Springs Mine Dump Seepage above Confluence with Willard Adit Discharge	IG-11	05/31/12	220	4.53	0.005	1.3	29	210	2700	140	2300	21	1.3	6000
		08/22/12	170	3.11	NA	1	22	180	3200	130	2600	23	1	6700
		06/05/13	320	2.76	NA	4.1	69	890	41000	240	4000	41	5.8	15000
		08/28/13	220	2.17	0.01	1.7	26	290	7600	130	2900	24	2.4	7100
		07/02/14	213	2.97	NC	2.16	53.1	557	9850	210	3730	28.3		11200
		09/18/14	204	3.44	N/C	2.8	24.1	113	8380	158	2930	16.6		7000
Iron Springs Gulch below Willard Adit Discharge and Mine Dump Seepage Confluence	IG-10	05/31/12	200	3.92	0.17	1.9	24	210	7100	140	2300	21	1.5	5600
		08/22/12	180	3.23	0.24	2.2	17	120	4500	90	2200	20	0.85	5100
		06/05/13	230	3.36	0.29	33	45	800	22000	300	3000	36	4.2	9500
		08/28/13	210	3.48	0.15	1.6	18	130	4600	130	2200	19	1.5	4800
		07/02/14	234	3.72	NC	1.17	32.6	270	8320	189	2600	20.6		7130
		09/18/14	217	3.57	N/C	1.78	21.6	109	6920	133	2700	14.2		6310
Iron Springs Gulch below Bright Hope Road	IG-09	05/31/12	130	7	0.41	0.22	11	30	640	6	1200	8	0.099	2300
		08/22/12	150	6.2	0.12	0.21	9.4	37	2200	4.3	1600	12	0.11	2800
		06/05/13	140	6.14	0.46	0.15	15	180	6400	7.7	950	12	0.3	3200
		08/28/13	180	6.4	0.18	0.42	7	19	1800	1.1	1100	8.3	0.17	2000
		07/02/14	150	6.85	0.629	<0.5	10.3	32.1	2120	0.987	824	6.44		2070
		09/18/14	161	6.72	0.141*	<0.5	7.03	11.7	1620	0.825	967	5.01		1880
Iron Springs Gulch above Little Mountain Confluence	IG-05	05/31/12	140	7.74	0.44	0.15	9.5	20	2900	0.37	930	9	0.075	2100
		08/22/12	140	6.95	0.09	0.19	7	12	1300	0.51	1100	8	0.082	2000
		06/05/13	140	6.5	0.44	0.15	15	110	1200	2.5	850	11	0.11	2700
		08/28/13	160	6.5	0.13	0.36	6	13	1400	0.53	940	6.7	0.16	1800
		07/02/14	138	7.04	0.629	<0.5	8.69	19.9	1850	0.514	713	5.24		1810
		09/18/14	151	7.23	0.285	<0.5	5.86	6.78	1090	0.496	754	4.18		1460

Table 4-2a
Iron Springs Gulch Hardness, pH, Flow Rate, and Dissolved Metal Results

Sample Location	Sample ID	Sample Date	Hardness (mg/L)	pH	Flow Rate (CFS)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Fe (T) (µg/L)	Pb (µg/L)	Mn (µg/L)	Ni (µg/L)	U (µg/L)	Zn (µg/L)
Iron Springs Gulch below Little Mountain Confluence	IG-04	05/31/12	130	7.29	0.35	0.58	***5.3***	11	***1600***	0.44	640	5	0.17	***1300***
		08/22/12	140	6.87	0.21	0.69	***3.2***	5	***1300***	0.55	690	5	0.24	***1200***
		06/05/13	140	7.41	0.65	0.34	***12***	***70***	***5400***	1.5	780	8.7	< 0.1	***2500***
		08/28/13	150	6.39	0.29	0.53	***3.2***	<4	***1800***	0.38	600	3.5	0.25	***990***
		07/02/14	138	7.16	0.724	<0.5	**6.73**	**14.9**	**1860**	0.533	622	4.8		**1480**
		09/18/14	147	6.71	0.33	<0.5	**4.24**	5.4	**1250**	0.404	619	5.84		**1180**

Notes:
< = Indicates that concentrations were reported below detection limits.
Bold and shaded values indicate concentrations that exceed benchmark screening levels.

µg/L = microgram per liter
As = Dissolved Arsenic
Cd = Dissolved Cadmium
CFS = cubic feet per second
Cu = Dissolved Copper
Fe (T) = Total Iron
ID = Identification
mg/L = milligram per liter
Mn = Dissolved Manganese
Pb = Dissolved Lead
U= Dissolved Uranium
Zn = Dissolved Zinc
Ni = Dissolved Nickel

Table 4-2b
Iron Springs Gulch Dissolved Zinc and Cadmium Loading Rates

Sample ID	Sample Date	Flow Rate (CFS)	Zn Loading (lbs/d)	Cd Loading (lbs/d)
IG-11	05/31/12	0.005	0.2	0.00082
	08/22/12	NA	NA	NA
	06/05/13	NA	NA	NA
	08/28/13	0.01	0.4	0.002
	07/02/14	NA	NA	NA
	09/18/14	NA	NA	NA
IG-10	05/31/12	0.17	5.2	0.022
	08/22/12	0.24	6.5	0.022
	06/05/13	0.29	15	0.071
	08/28/13	0.15	4.0	0.015
	07/02/14	NA	NA	NA
	09/18/14	NA	NA	NA
IG-09	05/31/12	0.41	5.0	0.024
	08/22/12	0.12	1.8	0.0060
	06/05/13	0.46	7.9	0.037
	08/28/13	0.18	2	0.0066
	07/02/14	0.63	7.02	0.03
	09/18/14	NA	NA	NA
IG-05	05/31/12	0.44	4.9	0.022
	08/22/12	0.09	1	0.003
	06/05/13	0.44	6.4	0.036
	08/28/13	0.13	1.3	0.004
	07/02/14	0.63	6.14	0.03
	09/18/14	0.29	2.25	0.01
IG-04	05/31/12	0.35	2.4	0.010
	08/22/12	0.21	1.4	0.0036
	06/05/13	0.65	8.8	0.042
	08/28/13	0.29	1.5	0.0049
	07/02/14	0.72	5.78	0.03
	09/18/14	0.33	2.10	0.01

Notes:
Cd = Dissolved Cadmium
CFS = cubic feet per second
ID = Identification
lbs/d = pounds per day
NA = Data not available
Zn = Dissolved Zinc

4.1.3 Little Mountain Springs Tributary Results

Sample locations included along the Little Mountain Spring Tributary include IG-06, IG-07 and IG-08. Two springs daylight at sample location IG-07. The tributary disappears beneath Boreas Pass Road downstream of sample location IG-06, although it likely enters Iron Springs Gulch on the north side of Boreas Pass Road near Brookside Lane.

Table 4-3a shows flow rates and concentrations of metals detected along the Little Mountain Spring tributary. Loading rates for cadmium and zinc are shown in Table 4-3b. Bar charts in Attachment D also provide summary information for these sample locations between 2012 and 2014.

Little Mountain Spring Tributary Sample Locations		
Site ID	**Site Description**	**Site Type**
IG-06	Little Mountain above Iron Springs Gulch Confluence	River/Stream
IG-07	Little Mountain Spring 2 – Spring above mine influence	Adit/ mine feature
IG-08	Iron Mtn. seep/ Little Mountain Spring 1 – Seep discharge	Adit/ mine feature

Flow Rates

The flow rate from Little Mountain Spring Tributary upstream sample point IG-08 ranges from 0.093 CFS in July 2014 during high-flow conditions and 0.01 CFS in August 2012 during low-flow conditions. The flow rates from downstream sample point IG-06 ranged from 0.11 CFS in June 2013 during high-flow conditions to 0.05 CFS in August 2012 during low-flow conditions.

Dissolved Metal Concentrations

Cadmium, iron, manganese, and zinc were detected at concentrations exceeding aquatic benchmark screening levels in this area. The highest metal concentrations and lowest pH values were detected in samples collected from the "Little Mountain Spring 1" seep discharge at sample point IG-08. Concentrations of dissolved manganese, arsenic, zinc and total iron are significantly lower in the sample for "Little Mountain Spring 2" as compared to Little Mountain Spring 1" while dissolved cadmium concentrations are the reverse of this. These two springs appear to represent separate sources of contamination to the drainage.

Concentrations of total hardness, zinc and cadmium for samples collected in 2014 for IG-07 and IG-08 appear as if they could be reversed when compared to data from 2012 and 2013. This may be worth confirming the exact sample locations relative to older sample locations for future sampling events.

Table 4-3a
Little Mountain Springs Tributary Hardness, pH, Flow Rate, and Dissolved Metal Results

Sample Location	Sample ID	Sample Date	Hardness (mg/L)	pH	Flow Rate (CFS)	As (µg/L)	Cd (µg/L)	Cu (µg/L)	Fe (T) (µg/L)	Pb (µg/L)	Mn (µg/L)	Ni (µg/L)	U (µg/L)	Zn (µg/L)	
Little Mountain Spring 1 - Seep discharge	IG-08	05/31/12	330	6.65	0.01	18	0.42	< 5	***18000***	3.8	2400	16	1.2	***3600***	12.5%
		08/22/12	320	6.42	0.01	16	0.31	< 5	***18200***	3.2	***2700***	17	1	***4100***	20
		06/05/13	340	7.38	0.03	15	0.4	< 4	***20200***	5.7	***2600***	17	1.1	***3900***	37.5
		08/28/13	340	5.44	0.01	16	0.29	< 4	***20000***	5.4	***2600***	15	1.1	***3500***	17 845%
		07/02/14	73	7.19	0.093	<0.5	**0.808**	1.18	<100	0.459	7.75	<0.5		152	
		09/18/14	98	6.86	0.0674	<0.5	**0.74**	0.75	<100	<0.1	<2	<0.5		103	74%
Little Mountain Spring 2 – Spring above mine influence	IG-07	05/31/12	90	7.34	0.08	0.19	***0.65***	< 5	8	< 0.15	< 2	< 2	0.29	100	
		08/22/12	97	6.83	0.05	0.22	***0.83***	< 5	< 4	< 0.15	< 2	< 2	0.29	***140***	
		06/05/13	89	7.84	0.08	0.34	***0.6***	< 4	47	0.46	< 2	< 1	0.22	110	
		08/28/13	100	6.35	0.06	0.23	***0.75***	4.3	17	0.28	< 2	< 1	0.32	110	
		07/02/14	354	6.54	0.011	13.9	<0.5	<2.5	21700	0.841	**3090**	15.8		**4720**	
		09/18/14	142	6.65	0.0917	1.69	**0.729**	0.735	3120	0.253	512	2.05		**800**	
Little Mountain above Iron Springs Gulch Confluence	IG-06	05/31/12	130	7.29	0.10	1.9	***0.62***	< 5	***2200***	0.28	430	4	0.43	***600***	
		08/22/12	150	6.99	0.05	1.7	***0.58***	< 5	**2100**	< 0.15	600	4	0.39	***820***	
		06/05/13	140	7.63	0.11	1.7	**1.6**	< 4	**2600**	0.73	510	3.5	0.32	**1000**	
		08/28/13	150	6.97	0.08	1.5	0.57	< 4	**2200**	0.31	410	1.9	0.39	**560**	
		07/02/14	132	7.11	0.106	1.72	**1.02**	0.93	**2370**	0.238	578	3.03		**1030**	
		09/18/14	144	6.52	0.0832	0.993	**0.698**	0.738	**2060**	0.128	498	2.2		**757**	

Notes:
< = Indicates that concentrations were reported below detection limits.
Bold and shaded values indicate concentrations that exceed benchmark screening levels.

µg/L = microgram per liter
As = Dissolved Arsenic
Cd = Dissolved Cadmium
CFS = cubic feet per second
Cu = Dissolved Copper
Fe (T) = Total Iron
ID = Identification
mg/L = milligram per liter
Mn = Dissolved Manganese
NA = Data not available
Pb = Dissolved Lead
U= Dissolved Uranium
Zn = Dissolved Zinc
Ni = Dissolved Nickel

Metal Loading Rates

Metal loading rates increase within Little Mountain Spring Tributary increase at sample point IG-06 above the Iron Springs Gulch confluence. The zinc loading results from dissolved concentrations at IG-08 and the cadmium load results are evidently contributed from inflow related to the spring at IG-07. Zinc and cadmium metal loading rates are shown in Table 4-3b below and the bar charts in Attachment D. Metal loading charts for zinc and cadmium oriented along the stream profile for each sampling event are also provided in the Charts section.

Table 4-3b
Little Mountain Springs Tributary Dissolved Zinc and Cadmium Loading Rates

Sample ID	Sample Date	Flow Rate (CFS)	Zn Loading (lbs/d)	Cd Loading (lbs/d)
IG-08	05/31/12	0.01	0.2	0.00002
	08/22/12	0.01	0.2	0.00002
	06/05/13	0.03	0.6	0.00006
	08/28/13	0.01	0.3	0.00002
	07/02/14	0.09	0.08	0.0004
	09/18/14	0.07	0.04	0.0003
IG-07	05/31/12	0.08	0.04	0.0003
	08/22/12	0.05	0.04	0.0002
	06/05/13	0.08	0.05	0.0003
	08/28/13	0.06	0.04	0.0003
	07/02/14	0.01	0.29	NA
	09/18/14	0.09	0.40	0.0004
IG-06	05/31/12	0.10	0.3	0.00033
	08/22/12	0.05	0.2	0.00015
	06/05/13	0.11	0.6	0.00093
	08/28/13	0.08	0.24	0.00025
	07/02/14	0.11	0.59	0.001
	09/18/14	0.08	0.34	0.0003

Notes:
Cd = Dissolved Cadmium
CFS = cubic feet per second
ID = Identification
lbs/d = pounds per day
Zn = Dissolved Zinc

4.1.4 Iron Springs Gulch Mine Site Feature Results

Sample points IG-13, IG-12, and IG-16 were collected within the Iron Springs Gulch and represent the Willard Adit 1, the Willard Pile or "mine dump", and Willard Adit 2 mine features, respectively. Locations IG-18 and IG-17 are located at the inlet and outlet, respectively, of the pond found south of the Willard Pile, and were added beginning in 2013.

Table 4-4a shows flow rates and concentrations of metals detected from the Iron Springs Gulch Mine Features. Loading rates for cadmium and zinc are shown in Table 4-4b. Bar charts in Attachment D also provide summary information for these sample locations between 2012 and 2014.

Iron Springs Gulch Mine Feature Sample Locations		
Site ID	Site Description	Site Type
IG-12	Iron Springs Mine Dump Seep	Adit/ mine feature
IG-13	Iron Springs Willard Adit Discharge. Puzzle Adit	Adit/ mine feature
IG-16	Puzzle Mine draining adit located 100 yards to the north of Puzzle Adit	Adit/ mine feature
IG-17	Outlet of beaver pond that is adjacent to waste rock piles	River/Stream
IG-18	Inlet of beaver pond that is adjacent to waste rock piles	River/Stream

Flow Rates

The flow rates from the Willard Adit 1at location IG-13 were measured to be 0.11 CFS in June 2013 during high-flow conditions and 0.04 CFS in August 2013 during low-flow conditions.

The flow rates from the Willard Adit 2 at IG-16 are lower, and were measured to be 0.02 CFS in June 2013 during high-flow conditions and 0.01 CFS in August 2012 during low-flow conditions. At sample point IG-16 flow rates were measured at 0.024 CFS in in August 2013 during low-flow conditions.

Flow rates measured at the inlet and outlet of the beaver pond located south of the Willard Pile are similar to and slightly higher than flow rates from the two adits.

Dissolved Metal Concentrations

Arsenic, cadmium, copper, total iron, lead, manganese, nickel, and zinc were detected at concentrations exceeding benchmark screening levels in samples from the two Willard Adits. The highest metal concentrations were detected in samples collected from the Willard Adit 1 discharge at sample point IG-13.

Concentrations of total iron that exceed the aquatic benchmark screening levels were detected at the IG-12 sample location. This location is a small seep located adjacent to the west side of the Willard Pile/mine dump. Cadmium and zinc concentrations exceeded the screening levels in May 2012, but have been below the screening level concentrations since that event.

Metals concentrations from samples IG-18 and IG-17, the pond inlet and outlet locations, were not above benchmark screening levels.

Metal Loading Rates

Metal loading rates were higher from the Willard Adit 1 drainage (IG-13) than the Willard Adit 2 drainage (IG-16). Loading rates for zinc at location IG-13 ranged between 1.3 and 7.4 lbs/d between 2012 and 2014. Loading rates for cadmium at location IG-13 ranged between 0.006 and 0.038 lbs/d between 2012 and 2014.

Flow measurements were not collected from sample location IG-12, which is located adjacent to the Willard Pile/mine dump. Therefore, zinc and cadmium loading rates could not be calculated at this location.

Zinc and cadmium metal loading rates are shown in Table 4-4b below and the bar charts in Attachment D. Metal loading charts for zinc and cadmium oriented along the stream profile for each sampling event are also provided in the Charts section.

Table 4-4b
Iron Springs Gulch Mine Features Dissolved Zinc and Cadmium Loading Rates

Sample ID	Sample Date	Flow Rate (CFS)	Zn Loading (lbs/d)	Cd Loading (lbs/d)
IG-13	05/31/12	0.05	2	0.01
	06/05/13	0.11	7.4	0.038
	08/28/13	0.04	1.3	0.006
	07/02/14	0.08	4.19	0.02
	09/18/14	0.06	2.64	0.01
IG-12	05/31/12	NA	NA	NA
	08/22/12	NA	NA	NA
	06/05/13	NA	NA	NA
	08/28/13	NA	NA	NA
	07/02/14	NA	NA	NA
	09/18/14	NA	NA	NA
IG-16	05/31/12	0.02	0.2	0.0004
	08/22/12	0.01	0.2	0.0004
	06/05/13	0.02	0.5	0.001
	08/28/13	0.01	0.2	0.0003
	07/02/14	0.01	0.23	0.001
	09/18/14	0.02	0.29	0.001
IG-17	07/16/13	0.039	NA	NA
	08/28/13	0.135	0.010	NA
	07/02/14	0.088	0.002	NA
	09/18/14	0.022	0.003	NA

Table 4-4b
Iron Springs Gulch Mine Features Dissolved Zinc and Cadmium Loading Rates

Sample ID	Sample Date	Flow Rate (CFS)	Zn Loading (lbs/d)	Cd Loading (lbs/d)
IG-18	07/16/13	0.034	NA	NA
	08/28/13	NA	0.012	0.00005
	07/02/14	0.065	0.001	NA
	09/18/14	0.011	NA	NA

Notes:
Cd = Dissolved Cadmium
CFS = cubic feet per second
ID = Identification
lbs/d = pounds per day
NA = Data not available
Zn = Dissolved Zinc

4.2 SUMMARY ILLINOIS GULCH FLOW AND METAL LOADING PROFILE

This section summarizes streamflow/discharge rates and metal loading for Illinois Gulch and Iron Springs Gulch based on the surface water quality sampling completed between 2012 and 2014.

The charts presented in the Charts section at the back of this report show the stream profile for Illinois and Iron Springs Gulches, stream discharge measurements along the profile, and zinc and cadmium loading rates along each profile for a number of surface water sampling locations.

Flow rates for Illinois Gulch and Iron Springs Gulch are plotted with zinc and cadmium loading rates on the line charts located at the back of this report, and also the bar charts in Attachment D. For Illinois Gulch, the flow rate increases between IG-15, the upstream sample location, to IG-01, the most downstream sample location. The highest measured stream flow was 5.89 CFS measured at location IG-01 in June of 2013. The lowest measured flow rate at IG-01 was 0.16 CFS in August of 2012.

The figures and charts show that discharge rates in Illinois Gulch are generally the highest at the IG-14 and IG-01 locations, and decline near the Iron Springs Gulch confluence, suggesting that Illinois gulch may lose some surface water to the alluvium in the area of the Iron Springs Gulch confluence. Interestingly, discharge rates measured at location IG-02, below the confluence with Iron Springs Gulch, and IG-01, the most downstream sample location (near the Ice Rink), shows a general downstream increase in discharge during high flow periods, and a decrease in flow rate during low flow periods.

The highest concentrations of zinc and cadmium are detected in samples from the Iron Springs Gulch area. The top three highest sample concentrations are at IG-11 (below the Willard Pile seep), IG-13 (Willard Adit 1), and IG-10 (below the confluence of the two Willard Adits and the Willard Pile seep). Not surprisingly, the highest loading rates calculated for zinc (15 lbs/d) and cadmium (0.07 lbs/d) are for location IG-10, where the two Willard Adit discharges combine with the Willard Pile seep flow.

Both the dissolved concentrations and loading rates for zinc and cadmium are generally greatest during high-flow stream conditions, and lower later in the summer season during the time of the low-flow event.

Zinc metal loading rates calculated at sample location IG-01 (most downstream sample location) range from approximately 0.4 lbs/day (August 2012) to 13 lbs/day (June 2013). Cadmium loading rates at this location range from 0.001 lbs/day (August 2012) to 0.07 lbs/day (June 2013). For these same dates, the zinc loading rates calculated at location IG-14 (location above Iron Springs Gulch confluence) range from 0.07 to 3 lbs/day, and for cadmium the loading rates range from 0.0003 to 0.01 lbs/day. This suggests that significant metal loading occurs to Illinois Gulch from discharge originating from Iron Springs Gulch (which also includes Little Mountain Spring Gulch loads).

Flow rates for Iron Springs Gulch are also shown in the metal loading charts. "Headwaters" of this tributary to Illinois Gulch are sourced from the two Willard Adits and the beaver pond, which are all located around the perimeter of the Willard mine waste pile(s) north of Boreas Pass Road inside the large hairpin or "U-shaped" turn. Flow rates at IG-05, located immediately above the confluence with Little Mountain Springs, range from approximately 0.1 CFS to 0.6 CFS. Calculated zinc loads range from approximately 1 to 6 lbs/day at IG-05, immediately upstream of the confluence with Little Mountain Spring tributary.

Flow rates in Iron Springs Gulch (IG-04) increase below the confluence with Little Mountain Springs. Little Mountain Springs (IG-06) contribute roughly one-fourth to one-third of the surface water in Iron Springs Gulch (IG-04) below the confluence with Little Mountain Springs. Water quality in the Little Mountain Springs tributary to Iron Springs Gulch is generally better (lower metals concentrations) than the water quality in Iron Springs Gulch above the confluence. However, water quality in Little Mountain Springs is consistently impacted by iron, cadmium, and zinc exceeding aquatic standards. Zinc metal loading rates calculated at sample location IG-06 (most downstream sample location but above the confluence with Iron Springs Gulch) range from approximately 0.2 lbs/day (August 2012) to 0.6 lbs/day (June 2013). Cadmium loading rates at this location range from 0.0001 lbs/day (August 2012) to 0.0009 lbs/day (June 2013).

5.1 SUMMARY

Water quality in Illinois Gulch is impacted by elevated concentrations of heavy metals, particularly cadmium and zinc. The origin of these elevated cadmium and zinc concentrations has been associated with natural geologic and anthropogenic impacts. The contribution from "natural geologic" sources is not readily apparent from the water quality data collected between 2012 and 2014. The most upstream sample location in the routine monitoring program is IG-15, but this location is downstream of the Larium and Mountain Pride mine sites. Opportunity samples were collected from these upstream areas in July and September of 2014, however the GPS coordinates did not match well with the written narrative and photo documentation, and so the data was not posted on the maps in this report or discussed directly in the text. Results from the opportunity samples collected in 2014 suggest that the headwaters of Illinois Gulch, which is the drainage located above the Mountain Pride mine tailings, has relatively low dissolved metals concentrations, and metal concentrations increase below the Mountain Pride and Larium Mine sites.

The anthropogenic impacts are clearly evident in the lower reach of Illinois Gulch. The greatest contribution to metal loading observed in Illinois Gulch is from Iron Springs Gulch. The origin of the elevated zinc and cadmium concentrations in Iron Spring Gulch are the two Willard adits and the Willard Pile or mine dump pile seeps. Additional metal loading is also contributed from the Little Mountain Spring(s).

Based on the results of data from the 2012-2014 sampling events, sample points located in the vicinity of the following mine sites reported elevated concentrations above benchmark screening levels of metals including cadmium and zinc:

- Willard Mine Adits 1 and 2
- Iron Springs Waste Rock Pile (Willard Pile) seeps
- Little Mountain Spring 1

CDPHE. 2009a. Regulation no. 31 – The Basic Standards and Methodologies for Surface Water (5 CCR 10002-31): Denver, Water Quality Control Commission, 55-56 p.

CDPHE. 2009b. Total Maximum Daily Load Assessment, Illinois Gulch. COUCBL12, Zinc. Summit County, Colorado. December 2009.

CDPHE. 2010. Total Maximum Daily Load Assessment, Illinois Gulch. COUCBL12, Cadmium. Summit County, Colorado. July 2011.

TechLaw. 2014. Sampling Trip Report, Illinois Gulch, Summit County, Colorado. July 2, 2014. Final. Prepared for USEPA, Contract: EP-W-13-028.

USEPA. 2011. Total Maximum Daily Load Assessment Illinois Gulch, COUCBL12, Cadmium Summit County, Colorado. July 2011

USEPA. 2015. Analytical Results – Illinois Gulch SW_SEP2014_A050/A-050. Letter transmittal dated 01/26/2015.

Site ID	Latitude (WGS 84)	Longitude (WGS 84)
IG-01	39.4724150	-106.0380350
IG-02	39.4715410	-106.0348070
IG-03	39.4715950	-106.0340200
IG-3-1	39.4712500	-106.0286150
IG-04	39.4705610	-106.0326340
IG-05	39.4705830	-106.0325210
IG-06	39.4703330	-106.0324400
IG-07	39.4698710	-106.0319190
IG-08	39.4699450	-106.0318650
IG-09	39.4699230	-106.0313690
IG-10	39.4694070	-106.0305320
IG-11	39.4692990	-106.0299290
IG-12	39.4687980	-106.0300910
IG-13	39.4687160	-106.0287820
IG-14	39.4667600	-106.0228683
IG-15	39.4624366	-106.0035100
IG-16	39.4694700	-106.0289680
IG-17	39.4684000	-106.0298200
IG-18	39.4679450	-106.0298633
IG-19	39.4703350	-106.0304633

Figure 1
Illinois Gulch Sample Location and Mining Features Map

Illinois Gulch
Appendix A: Water Quality Data Report

Site ID	Latitude (WGS 84)	Longitude (WGS 84)
IG-01	39.4724150	-106.0390350
IG-02	39.4716410	-106.0346010
IG-03	39.4715950	-106.0340200
IG-3-1	39.4712500	-106.0286150
IG-04	39.4706810	-106.0326340
IG-05	39.4705830	-106.0325210
IG-06	39.4703330	-106.0324400
IG-07	39.4699710	-106.0319190
IG-08	39.4699460	-106.0318850
IG-09	39.4699230	-106.0313690
IG-10	39.4694070	-106.0300320
IG-11	39.4692990	-106.0299290
IG-12	39.4687560	-106.0300810
IG-13	39.4687160	-106.0287820
IG-14	39.4687600	-106.0228883
IG-15	39.4634200	-106.0035190
IG-16	39.4694700	-106.0389680
IG-17	39.4684000	-106.0298200
IG-18	39.4679450	-106.0298833
IG-19	39.4703350	-106.0304633

Figure 2
Willard Mine and
Little Mountain Spring Site Map
Illinois Gulch
Appendix A. Water Quality Data Report

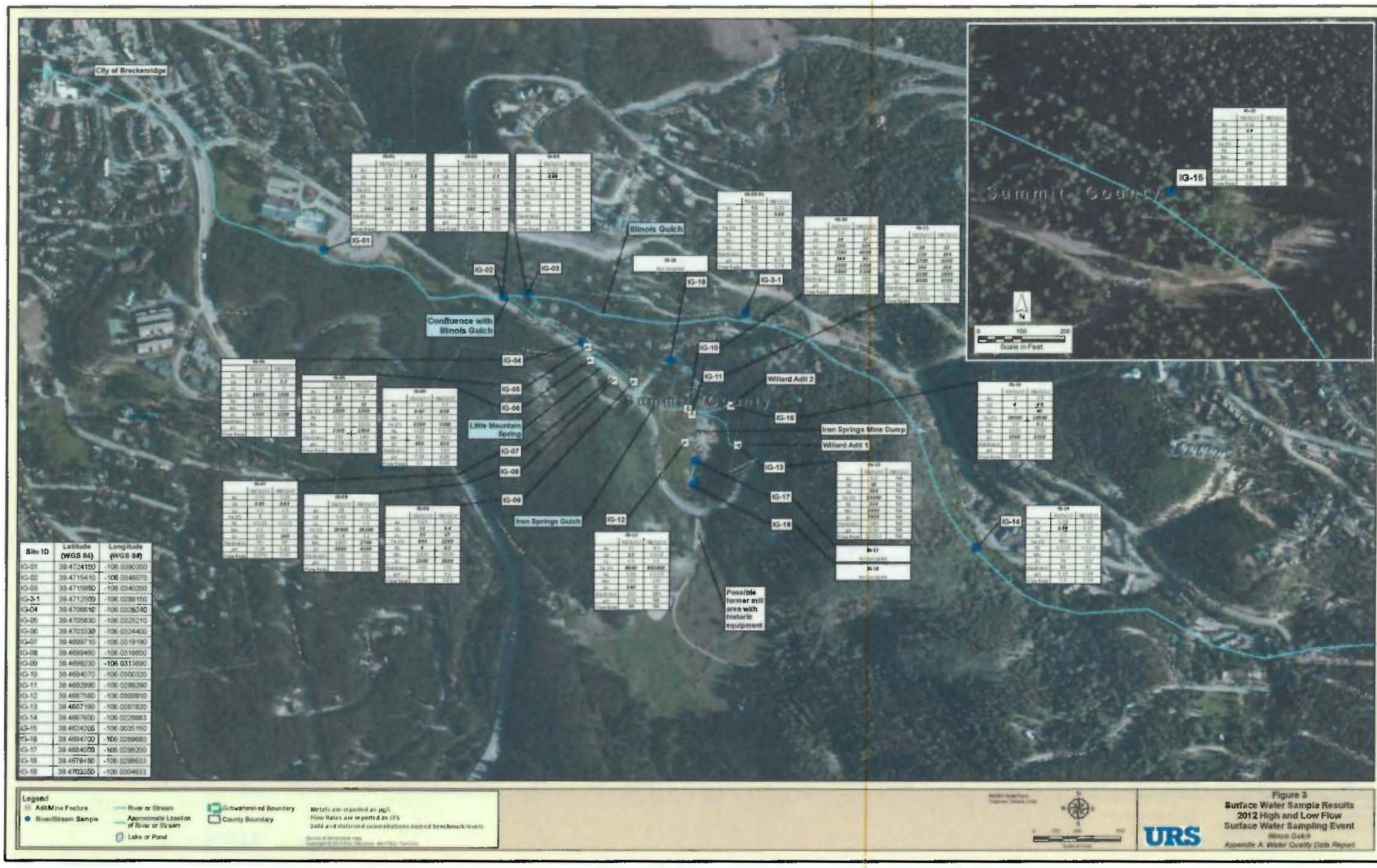
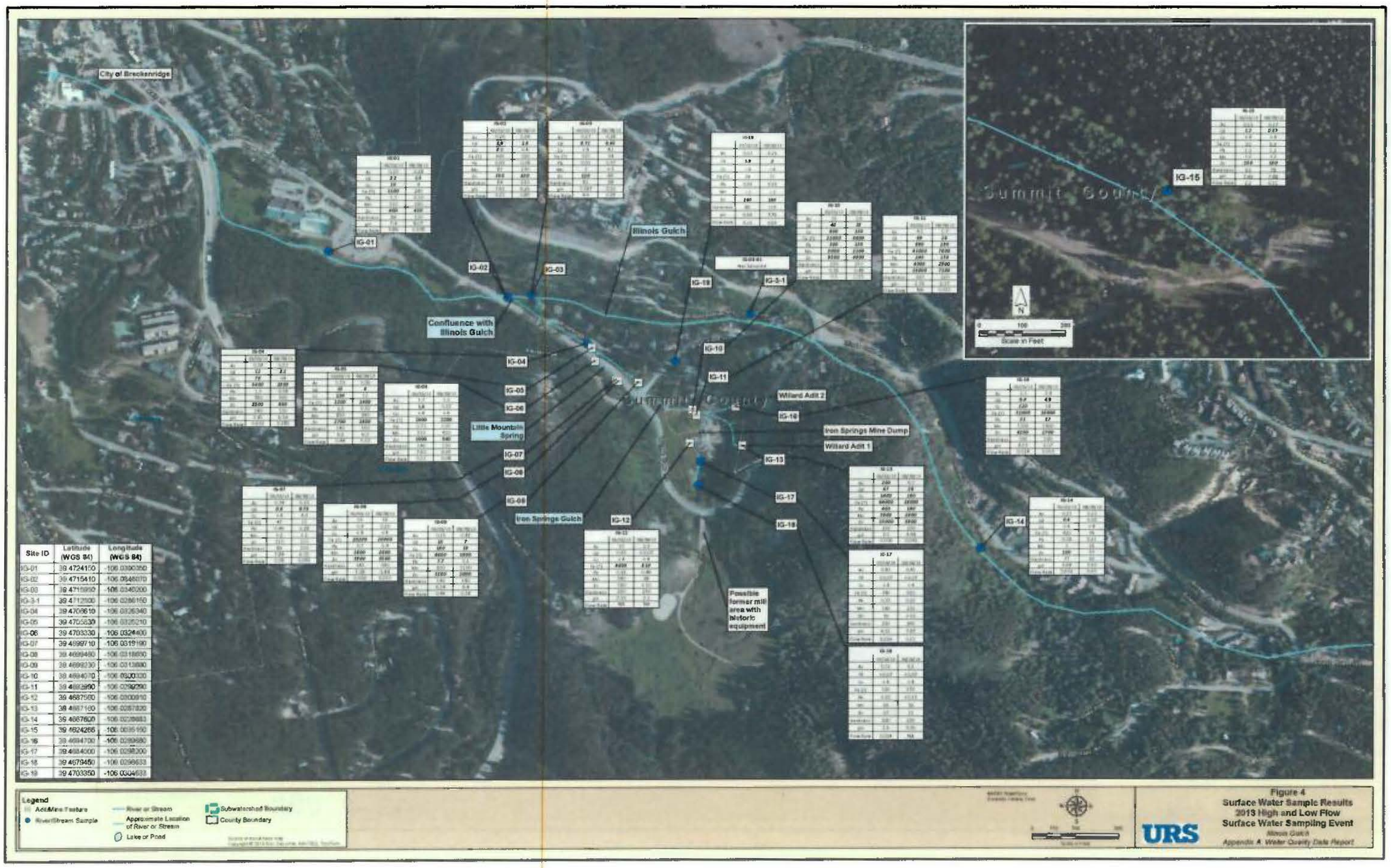
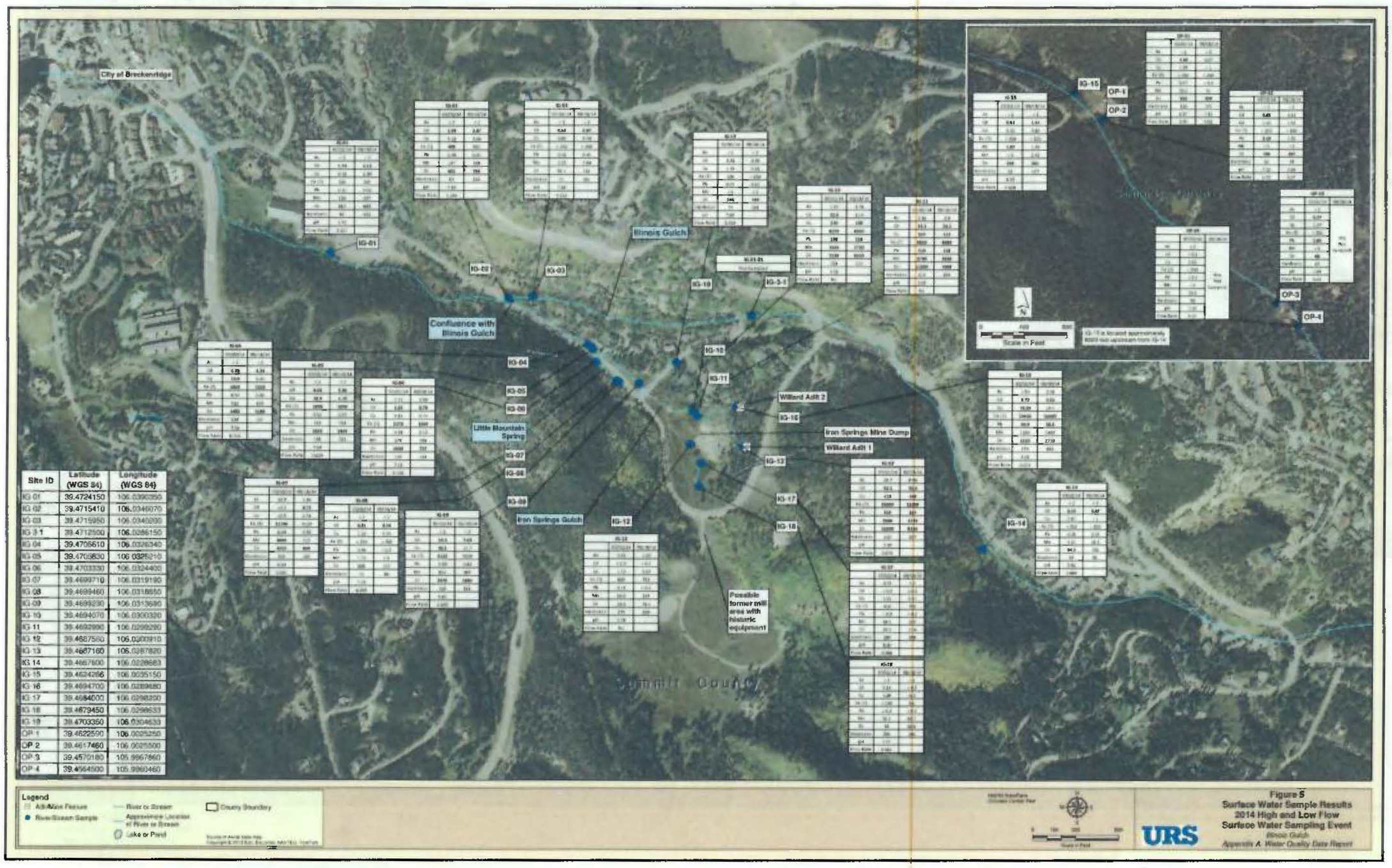


Figure 3
Surface Water Sample Results
2012 High and Low Flow
Surface Water Sampling Event
Appendix A: Water Quality Data Report

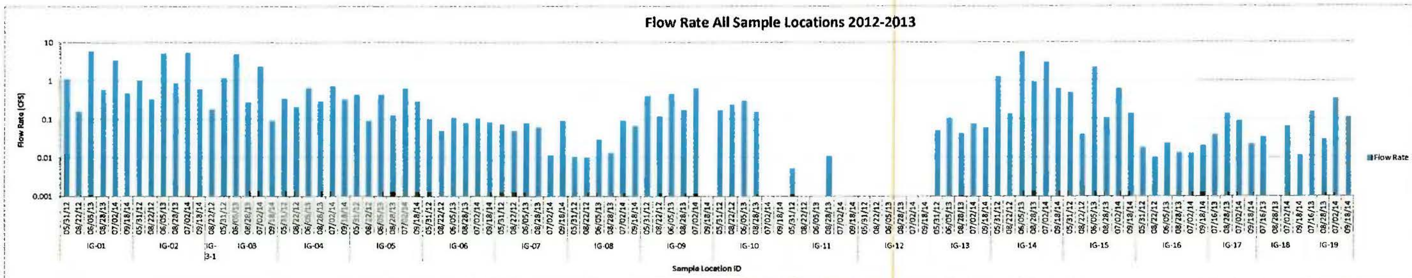


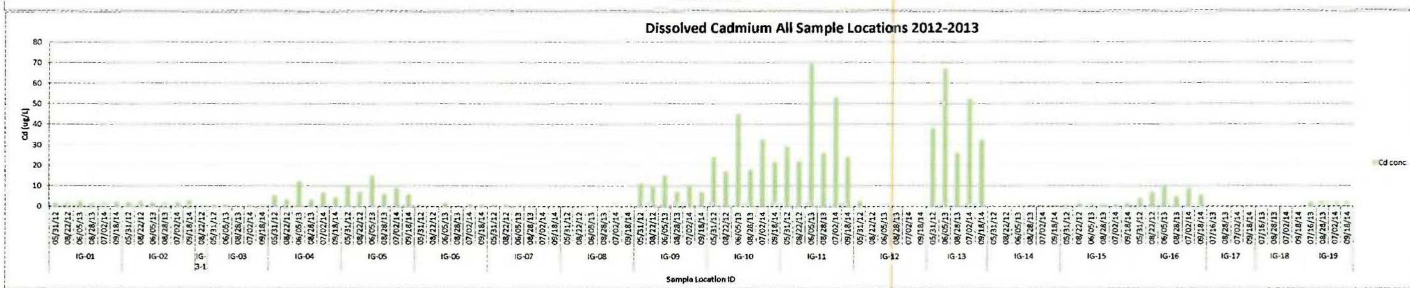
Site ID	Latitude (WGS 84)	Longitude (WGS 84)
IG-01	39.4724150	-106.0390350
IG-02	39.4715410	-106.0346070
IG-03	39.4715950	-106.0340200
IG-3-1	39.4712500	-106.0286150
IG-04	39.4706610	-106.0326340
IG-05	39.4705830	-106.0325210
IG-06	39.4703330	-106.0324400
IG-07	39.4699710	-106.0319190
IG-08	39.4699480	-106.0318690
IG-09	39.4699230	-106.0313690
IG-10	39.4694070	-106.0300320
IG-11	39.4693990	-106.0299290
IG-12	39.4687560	-106.0300910
IG-13	39.4687160	-106.0287820
IG-14	39.4667600	-106.0208883
IG-15	39.4624266	-106.0035150
IG-16	39.4694700	-106.0289680
IG-17	39.4684000	-106.0298200
IG-18	39.4679450	-106.0296833
IG-19	39.4703350	-106.0304833

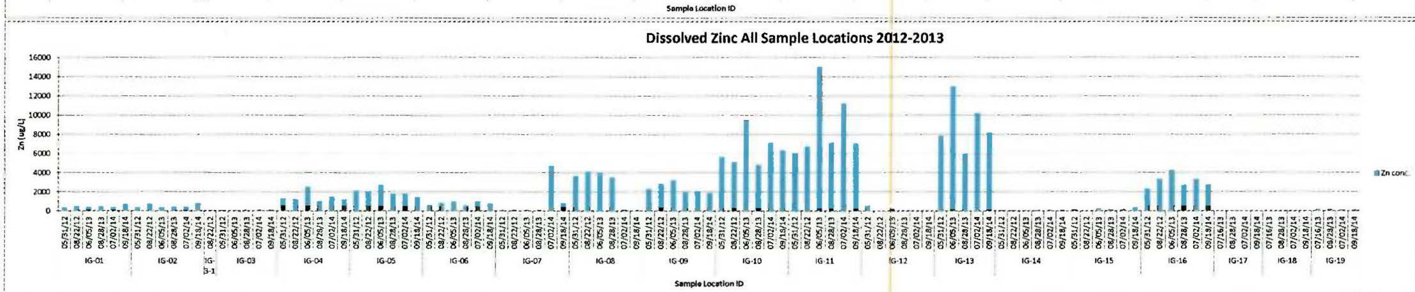
Figure 4
Surface Water Sample Results
2013 High and Low Flow
Surface Water Sampling Event
Illinois Gulch
Appendix A: Water Quality Data Report

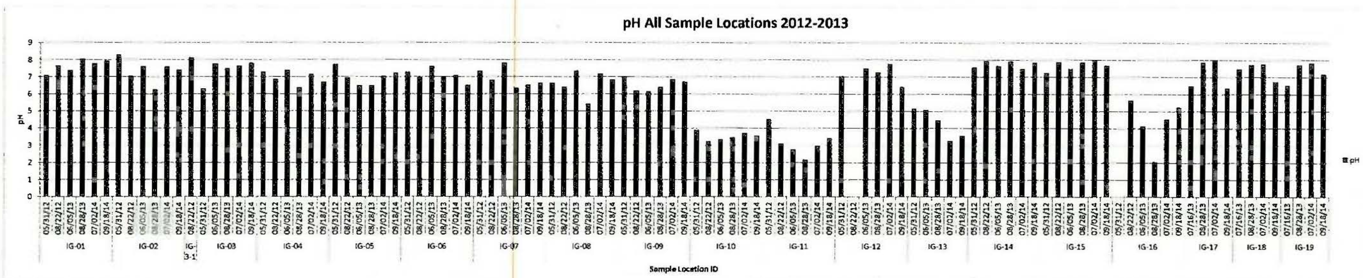


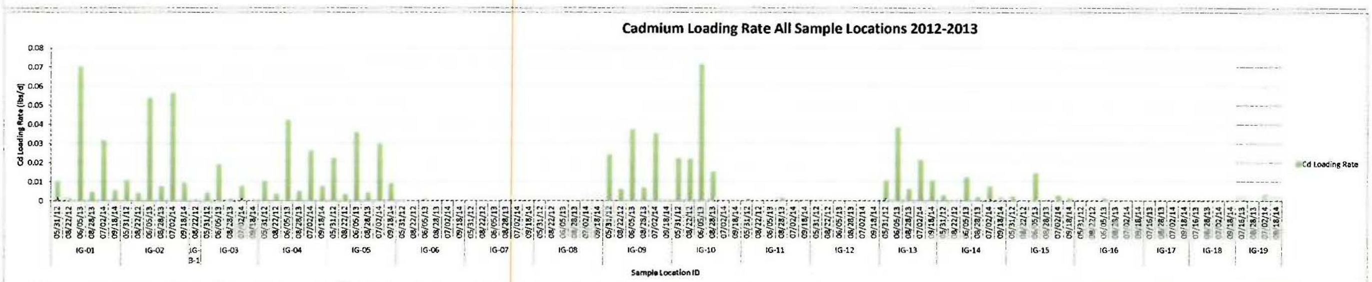
City of Breckenridge
IG-01
IG-02
IG-03
Illinois Gulch
Confluence with Illinois Gulch
IG-04
IG-05
IG-06
Little Mountain Spring
IG-07
IG-08
IG-09
Iron Springs Gulch
IG-10
IG-11
IG-3-1
IG-19
Willard Adit 2
IG-16
Iron Springs Mine Dump
Willard Adit 1
IG-13
IG-12
IG-17
IG-18
Possible former mill area with historic equipment
IG-14
Summit County
IG-15
OP-1
OP-2
OP-3
OP-4
Scale in Feet
Legend
River/Stream Sample
Lake or Pond
County Boundary
Figure 5
Surface Water Sample Results
2014 High and Low Flow
Surface Water Sampling Event
Appendix A. Water Quality Data Report

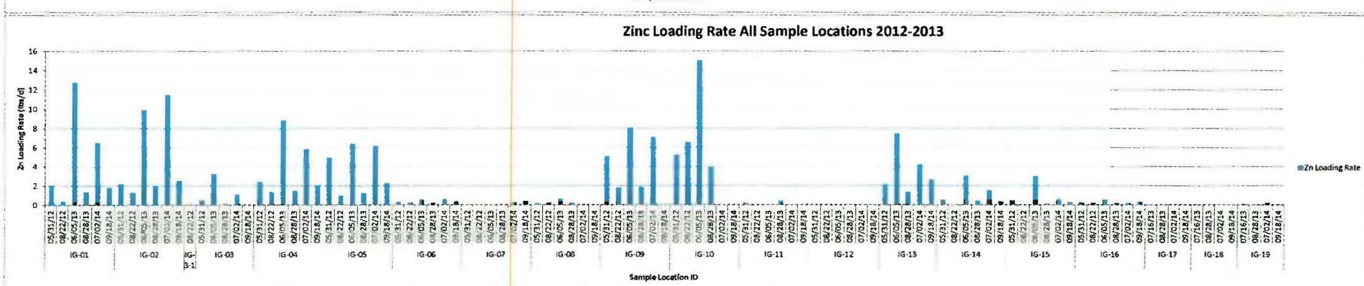

Flow Rate All Sample Locations 2012-2013
Flow Rate (CFS)
Flow Rate
Sample Location ID
IG-01 IG-02 IG-3-1 IG-03 IG-04 IG-05 IG-06 IG-07 IG-08 IG-09 IG-10 IG-11 IG-12 IG-13 IG-14 IG-15 IG-16 IG-17 IG-18 IG-19


Dissolved Cadmium All Sample Locations 2012-2013
Cd (ug/L)
Cd conc
Sample Location ID
IG-01 IG-02 IG-3-1 IG-03 IG-04 IG-05 IG-06 IG-07 IG-08 IG-09 IG-10 IG-11 IG-12 IG-13 IG-14 IG-15 IG-16 IG-17 IG-18 IG-19


Dissolved Zinc All Sample Locations 2012-2013
Zn (ug/L)
Zn conc
Sample Location ID
IG-01 IG-02 IG-3-1 IG-03 IG-04 IG-05 IG-06 IG-07 IG-08 IG-09 IG-10 IG-11 IG-12 IG-13 IG-14 IG-15 IG-16 IG-17 IG-18 IG-19


pH All Sample Locations 2012-2013
pH
Sample Location ID
IG-01
IG-02
IG-3-1
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
IG-09
IG-10
IG-11
IG-12
IG-13
IG-14
IG-15
IG-16
IG-17
IG-18
IG-19


Cadmium Loading Rate All Sample Locations 2012-2013
Cd Loading Rate (lbs/d)
Cd Loading Rate
Sample Location ID
IG-01
IG-02
IG-3-1
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
IG-09
IG-10
IG-11
IG-12
IG-13
IG-14
IG-15
IG-16
IG-17
IG-18
IG-19


Zinc Loading Rate All Sample Locations 2012-2013
Zn Loading Rate (lbs/d)
Zn Loading Rate
Sample Location ID
IG-01
IG-02
IG-3-1
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
IG-09
IG-10
IG-11
IG-12
IG-13
IG-14
IG-15
IG-16
IG-17
IG-18
IG-19

Attachment A
Surface Water Hardness Adjusted Benchmark Tables

Attachment A-1
Surface Water Hardness Adjusted Benchmark Comparison
Illinois Gulch
May 31, 2012 (High Flow)

Sample	Sample ID	Hardness	Total Iron[b]	Arsenic[a]	Cadmium[a]	Chromium[a]	Copper[a]	Lead[a]	Manganese[a]	Mercury[a]	Nickel[a]	Selenium[a]	Silver[a]	Zinc[a]
		(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Illinois Gulch at Ice Arena	IG-01	98	410	0.32	***1.7***	< 1	< 5	0.54	160	< ***0.05***	< 2	0.29	< 0.07	***340***
hardn. adj. benchm.			1000	150	0.42	73	8.80	2.46	1639	0.002	51	4.6	0.073	122
Illinois Gulch below Iron Springs Gulch confluence	IG-02	97	490	0.31	***1.9***	< 1	< 5	0.38	170	< ***0.05***	< 2	< 0.17	< 0.07	***390***
hardn. adj. benchm.			1000	150	0.41	72	8.73	2.43	1633	0.002	51	4.6	0.071	121
Illinois Gulch above Iron Springs Gulch confluence	IG-03	86	36	0.25	***0.66***	< 1	< 5	< 0.15	3	< ***0.05***	< 2	< 0.17	< ***0.07***	77
hardn. adj. benchm.			1000	150	0.38	66	7.87	2.13	1569	0.002	46	4.6	0.058	109
Iron Springs Gulch below Little Mountain confluence	IG-04	130	***1600***	0.58	***5.3***	< 1	11	0.44	640	< ***0.05***	5	< 0.17	< 0.07	***1300***
hardn. adj. benchm.			1000	150	0.51	92	11.21	3.34	1800	0.002	65	4.6	0.118	155
Iron Springs Gulch above Little Mountain confluence	IG-05	140	***2900***	0.15	***9.5***	< 1	***20***	0.37	930	< ***0.05***	9	< 0.17	< 0.07	***2100***
hardn. adj. benchm.			1000	150	0.54	98	11.94	3.62	1845	0.002	69	4.6	0.134	166
Little Mountain above Iron Springs Gulch Confluence	IG-06	130	***2200***	1.9	***0.62***	< 1	< 5	0.28	430	< ***0.05***	4	0.31	< 0.07	***600***
hardn. adj. benchm.			1000	150	0.51	92	11.21	3.34	1800	0.002	65	4.6	0.118	155
Little Mountain Spring 2 - Spring above mine influence	IG-07	90	8	0.19	***0.65***	< 1	< 5	< 0.15	< 2	< ***0.05***	< 2	0.2	< ***0.07***	100
hardn. adj. benchm.			1000	150	0.39	68	8.18	2.24	1593	0.002	48	4.6	0.063	114
Little Mountain Spring 1 - Seep discharge	IG-08	330	***18000***	18	0.42	< 1	< 5	3.8	2400	< ***0.05***	16	< 0.17	< 0.07	***3600***
hardn. adj. benchm.			1000	150	1.04	197	24.84	8.97	2455	0.002	143	4.6	0.585	344
Iron Springs Gulch below Bright Hope Road	IG-09	130	640	0.22	***11***	< 1	***30***	***6***	1200	< ***0.05***	8	< 0.17	< 0.07	***2300***
hardn. adj. benchm.			1000	150	0.51	92	11.21	3.34	1800	0.002	65	4.6	0.118	155
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence.	IG-10	200	***7100***	1.9	***24***	< 1	***210***	***140***	***2300***	< ***0.05***	21	< 0.17	< 0.07	***5600***
hardn. adj. benchm.			1000	150	0.71	131	16.19	5.31	2078	0.002	93	4.6	0.247	224
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge.	IG-11	220	***2700***	1.3	***29***	1	***210***	***140***	***2300***	< ***0.05***	21	< 0.17	< 0.07	***6000***
hardn. adj. benchm.			1000	150	0.76	141	17.57	5.87	2145	0.002	101	4.6	0.291	243
Iron Springs mine dump Seep A.	IG-12	250	***6900***	11	***2.5***	< 1	< 5	0.42	570	< ***0.05***	< 2	< 0.17	< 0.07	***540***
hardn. adj. benchm.			1000	150	0.84	157	19.60	6.72	2238	0.002	113	4.6	0.363	271
Iron Springs Willard Adit 1	IG-13	180	***23000***	6.2	***38***	< 1	***390***	***220***	***2600***	< ***0.05***	29	< 0.17	< 0.07	***7800***
hardn. adj. benchm.			1000	150	0.66	120	14.80	4.74	2006	0.002	86	4.6	0.206	205
Illinois Gulch at Illinois Gulch Road	IG-14	84	460	0.18	***0.39***	< 1	< 5	< 0.15	5	< ***0.05***	< 2	< 0.17	< ***0.07***	79
hardn. adj. benchm.			1000	150	0.37	64	7.72	2.08	1557	0.002	45	4.6	0.056	107
Illinois Gulch headwaters	IG-15	78	36	0.16	***0.9***	< 1	< 5	0.39	< 2	< ***0.05***	< 2	< 0.17	< ***0.07***	***170***
hardn. adj. benchm.			1000	150	0.35	60	7.24	1.92	1519	0.002	42	4.6	0.049	101
Willard Adit 2 located 100 yards north of Willard Adit 1 discharge at IG-13	IG-16	200	***19000***	3	***4***	< 1	7	3.9	1300	< ***0.05***	16	< 0.17	< 0.07	***2300***
hardn. adj. benchm.			1000	150	0.71	131	16.19	5.31	2078	0.002	93	4.6	0.247	224

Notes:
- All results are reported as dissolved with the exception of iron which is reported in the total fraction.
- Benchmarks are hardness adjusted for Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn
- Bold values indicate exceedance of hardness - adjusted benchmark
- Selenium and mercury can bioaccumulate in food chains. The benchmarks in this spreadsheet are solely for screening purposes. Other site-specific values may be more appropriate.

a: Colorado Department of Public Health and the Environment (CDPHE), 2009. Regulation no. 31 – The basic standards and methodologies for surface water (5 CCR 1002 – 31): Denver, Water Quality Control Commission, 55-56 p.

b. Iron trec standard for Illinois Gulch segment is 1,000 µg/L
< The analyte result is a Non-detect below the laboratory reporting limit

Attachment A-2

Surface Water Hardness Adjusted Benchmark Comparison

Illinois Gulch

August 22, 2012 (Low Flow)

Sample	Sample ID	Hardness (mg/L)	Total Iron[b] (µg/L)	Arsenic[a] (µg/L)	Cadmium[a] (µg/L)	Chromium[a] (µg/L)
Illinois Gulch at Ice Arena	IG-01	120	110	0.27	**1.6**	< 1
hardn. adj. benchm.			1000	150	0.48	86
Illinois Gulch below Iron Springs Gulch confluence	IG-02	120	420	0.4	**2.3**	< 1
hardn. adj. benchm.			1000	150	0.48	86
Illinois Gulch above Iron Springs Gulch confluence	IG-03	--	--	--	--	--
hardn. adj. benchm.			1000			
Illinois Gulch above Iron Springs Gulch Confluence	IG-03-01	96	9	0.33	**0.66**	< 1
hardn. adj. benchm.			1000	150	0.41	72
Iron Springs Gulch below Little Mountain confluence	IG-04	140	**1300**	0.69	**3.2**	< 1
hardn. adj. benchm.			1000	150	0.54	98
Iron Springs Gulch above Little Mountain confluence	IG-05	140	**1300**	0.19	**7**	< 1
hardn. adj. benchm.			1000	150	0.54	98
Little Mountain above Iron Springs Gulch Confluence	IG-06	150	**2100**	1.7	**0.58**	< 1
hardn. adj. benchm.			1000	150	0.57	103
Little Mountain Spring 2 - Spring above mine influence	IG-07	97	22	0.22	**0.83**	< 1
hardn. adj. benchm.			1000	150	0.41	72
Little Mountain Spring 1 - Seep discharge	IG-08	320	**18200**	16	0.31	< 1
hardn. adj. benchm.			1000	150	1.01	192
Iron Springs Gulch below Bright Hope Road	IG-09	150	**2200**	0.21	**9.4**	< 1
hardn. adj. benchm.			1000	150	0.57	103
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence	IG-10	180	**4500**	2.2	**17**	< 1
hardn. adj. benchm.			1000	150	0.66	120
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge	IG-11	170	**3200**	1	**22**	< 1
hardn. adj. benchm.			1000	150	0.63	114
Iron Springs mine dump Seep A.	IG-12	380	**962000**	4.5	< 0.07	< 1
hardn. adj. benchm.			1000	150	1.15	221
Iron Springs Willard Adit 1 discharge.	IG-13	--	--	--	--	--
hardn. adj. benchm.			1000			
Illinois Gulch at Illinois Gulch Road	IG-14	91	30	0.23	0.37	< 1
hardn. adj. benchm.			1000	150	0.39	69
Illinois Gulch headwaters	IG-15	96	110	0.16	**1.5**	< 1
hardn. adj. benchm.			1000	150	0.41	72
Willard Adit 2 located 100 yards north of Willard Adit 1 discharge at IG-13	IG-16	190	**14900**	2.4	**6.9**	< 1
hardn. adj. benchm.			1000	150	0.68	125

Sample	Copper[a] (µg/L)	Lead[a] (µg/L)	Manganese[a] (µg/L)	Mercury[a] (µg/L)
Illinois Gulch at Ice Arena	< 5	< 0.15	260	< **0.05**
hardn. adj. benchm.	10.47	3.07	1753	0.002
Illinois Gulch below Iron Springs Gulch confluence	< 5	0.21	380	< **0.05**
hardn. adj. benchm.	10.47	3.07	1753	0.002
Illinois Gulch above Iron Springs Gulch confluence	--	--	--	--
hardn. adj. benchm.				
Illinois Gulch above Iron Springs Gulch Confluence	< 5	0.18	3	< **0.05**
hardn. adj. benchm.	8.65	2.41	1627	0.002
Iron Springs Gulch below Little Mountain confluence	5	0.55	690	< **0.05**
hardn. adj. benchm.	11.94	3.62	1845	0.002
Iron Springs Gulch above Little Mountain confluence	**12**	0.51	1100	< **0.05**
hardn. adj. benchm.	11.94	3.62	1845	0.002
Little Mountain above Iron Springs Gulch Confluence	< 5	< 0.15	600	< **0.05**
hardn. adj. benchm.	12.66	3.90	1888	0.002
Little Mountain Spring 2 - Spring above mine influence	< 5	< 0.15	< 2	< **0.05**
hardn. adj. benchm.	8.73	2.43	1633	0.002
Little Mountain Spring 1 - Seep discharge	< 5	3.2	**2700**	< **0.05**
hardn. adj. benchm.	24.20	8.69	2430	0.002
Iron Springs Gulch below Bright Hope Road	**37**	**4.3**	1600	< **0.05**
hardn. adj. benchm.	12.66	3.90	1888	0.002
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence	**120**	**90**	**2200**	< **0.05**
hardn. adj. benchm.	14.80	4.74	2006	0.002
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge	**180**	**130**	**2600**	< **0.05**
hardn. adj. benchm.	14.09	4.46	1969	0.002
Iron Springs mine dump Seep A.	< 5	< 0.15	170	< **0.05**
hardn. adj. benchm.	28.02	10.38	2573	0.002
Iron Springs Willard Adit 1 discharge.	--	--	--	--
hardn. adj. benchm.				
Illinois Gulch at Illinois Gulch Road	< 5	< 0.15	17	< **0.05**
hardn. adj. benchm.	8.26	2.27	1599	0.002
Illinois Gulch headwaters	< 5	0.5	< 2	< **0.05**
hardn. adj. benchm.	8.65	2.41	1627	0.002
Willard Adit 2 located 100 yards north of Willard Adit 1 discharge at IG-13	**43**	**5.1**	1700	< **0.05**
hardn. adj. benchm.	15.50	5.02	2043	0.002

Sample	Nickel[a] (µg/L)	Selenium[a] (µg/L)	Silver[a] (µg/L)	Zinc[a] (µg/L)
Illinois Gulch at Ice Arena	< 2	< 0.17	< **0.7**	**480**
hardn. adj. benchm.	61	4.6	0.103	145
Illinois Gulch below Iron Springs Gulch confluence	3	< 0.17	< **0.7**	**740**
hardn. adj. benchm.	61	4.6	0.103	145
Illinois Gulch above Iron Springs Gulch confluence	--	--	--	--
hardn. adj. benchm.				
Illinois Gulch above Iron Springs Gulch Confluence	< 2	< 0.17	< **0.7**	110
hardn. adj. benchm.	50	4.6	0.070	120
Iron Springs Gulch below Little Mountain confluence	5	< 0.17	< **0.7**	**1200**
hardn. adj. benchm.	69	4.6	0.134	166
Iron Springs Gulch above Little Mountain confluence	8	< 0.17	< **0.7**	**2000**
hardn. adj. benchm.	69	4.6	0.134	166
Little Mountain above Iron Springs Gulch Confluence	4	< 0.17	< **0.7**	**820**
hardn. adj. benchm.	73	4.6	0.151	176
Little Mountain Spring 2 - Spring above mine influence	< 2	< 0.17	< **0.7**	**140**
hardn. adj. benchm.	51	4.6	0.071	121
Little Mountain Spring 1 - Seep discharge	17	< 0.17	< **0.7**	**4100**
hardn. adj. benchm.	139	4.6	0.555	335
Iron Springs Gulch below Bright Hope Road	12	< 0.17	< **0.7**	**2800**
hardn. adj. benchm.	73	4.6	0.151	176
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence	20	< 0.17	< **0.7**	**5100**
hardn. adj. benchm.	86	4.6	0.206	205
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge	23	< 0.17	< **0.7**	**6700**
hardn. adj. benchm.	81	4.6	0.187	195
Iron Springs mine dump Seep A.	< 2	< 0.17	< 0.7	51
hardn. adj. benchm.	161	4.6	0.746	388
Iron Springs Willard Adit 1 discharge.	--	--	--	--
hardn. adj. benchm.				
Illinois Gulch at Illinois Gulch Road	< 2	< 0.17	< **0.7**	100
hardn. adj. benchm.	48	4.6	0.064	115
Illinois Gulch headwaters	< 2	< 0.17	< **0.7**	13
hardn. adj. benchm.	50	4.6	0.070	120
Willard Adit 2 located 100 yards north of Willard Adit 1 discharge at IG-13	20	< 0.17	< **0.7**	**3300**
hardn. adj. benchm.	90	4.6	0.226	215

Notes:

- All results are reported as dissolved with the exception of iron which is reported in the total fraction.
- Benchmarks are hardness adjusted for Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn
- Bold values indicate exceedance of hardness - adjusted benchmark.
- Selenium and mercury can bioaccumulate in food chains. The benchmarks in this spreadsheet are solely for screening purposes. Other site-specific values may be more appropriate.

a. Colorado Department of Public Health and the Environment (CDPHE), 2009. Regulation no. 31 – The basic standards and methodologies for surface water (5 CCR 1002 – 31): Denver, Water Quality Control Commission, 55-56 p.

b. Iron trec standard for Illinois Gulch segment is 1,000 µg/L

< The analyte result is a Non-detect below the laboratory reporting limit

Attachment A-3
Surface Water Hardness Adjusted Benchmark Comparison
Illinois Gulch
June 5, 2013 (High Flow)

Sample	Sample ID	Hardness (mg/L)	Total Iron[b] (µg/L)	Arsenic[a] (µg/L)	Cadmium[a] (µg/L)	Chromium[a] (µg/L)	Copper[a] (µg/L)	Lead[a] (µg/L)	Manganese[a] (µg/L)	Mercury[a] (µg/L)	Nickel[a] (µg/L)	Selenium[a] (µg/L)	Silver[a] (µg/L)	Zinc[a] (µg/L)
Illinois Gulch at Ice Arena	IG-01	89	***1100***	0.25	***2.2***	< 1	***10***	1.3	110	< ***0.05***	2.1	0.33	< ***0.7***	***400***
hardn. adj. benchm.			1000	150	0.39	67	8.11	2.22	1587	0.002	47	4.6	0.061	113
Illinois Gulch below Iron Springs Gulch confluence	IG-02	84	690	0.26	***1.9***	< 1	***8.1***	0.91	87	< ***0.05***	1.7	0.28	< ***0.7***	***350***
hardn. adj. benchm.			1000	150	0.37	64	7.72	2.08	1557	0.002	45	4.6	0.056	107
Illinois Gulch above Iron Springs Gulch confluence	IG-03	82	310	0.27	***0.71***	< 1	< 4	0.51	3	< ***0.05***	< 1	0.33	< ***0.7***	***120***
hardn. adj. benchm.			1000	150	0.36	63	7.56	2.03	1544	0.002	44	4.6	0.053	105
Illinois Gulch above Iron Springs Gulch Confluence.	IG-03-01	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Gulch below Little Mountain confluence	IG-04	140	***5400***	0.34	***12***	< 1	***70***	1.5	780	< ***0.05***	8.7	0.26	< ***0.7***	***2500***
hardn. adj. benchm.			1000	150	0.54	98	11.94	3.62	1845	0.002	69	4.6	0.134	166
Iron Springs Gulch above Little Mountain confluence	IG-05	140	***1200***	0.15	***15***	< 1	***110***	2.5	850	< ***0.05***	11	0.24	< ***0.7***	***2700***
hardn. adj. benchm.			1000	150	0.54	98	11.94	3.62	1845	0.002	69	4.6	0.134	166
Little Mountain above Iron Springs Gulch Confluence	IG-06	140	***2600***	1.7	***1.6***	< 1	< 4	0.73	510	< ***0.05***	3.5	0.24	< ***0.7***	***1000***
hardn. adj. benchm.			1000	150	0.54	98	11.94	3.62	1845	0.002	69	4.6	0.134	166
Little Mountain Spring 2 - Spring above mine influence	IG-07	89	47	0.34	***0.6***	< 1	< 4	0.46	< 2	< ***0.05***	< 1	0.34	< ***0.7***	110
hardn. adj. benchm.			1000	150	0.39	67	8.11	2.22	1587	0.002	47	4.6	0.061	113
Little Mountain Spring 1 - Seep discharge	IG-08	340	***20200***	15	0.4	< 1	< 4	5.7	***2600***	< ***0.05***	17	< 0.17	< ***0.7***	***3900***
hardn. adj. benchm.			1000	150	1.06	202	25.48	9.26	2480	0.002	146	4.6	0.616	353
Iron Springs Gulch below Bright Hope Road	IG-09	140	***6400***	0.15	***15***	< 1	***180***	***7.7***	950	< ***0.05***	12	0.31	< ***0.7***	***3200***
hardn. adj. benchm.			1000	150	0.54	98	11.94	3.62	1845	0.002	69	4.6	0.134	166
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence.	IG-10	230	***22000***	33	***45***	< 1	***800***	***300***	***3000***	< ***0.05***	36	0.23	< ***0.7***	***9500***
hardn. adj. benchm.			1000	150	0.79	147	18.25	6.15	2177	0.002	105	4.6	0.315	253
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge.	IG-11	320	***41000***	4.1	***69***	2.8	***890***	***240***	***4000***	< ***0.05***	41	0.25	< ***0.7***	***15000***
hardn. adj. benchm.			1000	150	1.01	192	24.20	8.69	2430	0.002	139	4.6	0.555	335
Iron Springs mine dump Seep A.	IG-12	290	***9600***	10	0.63	< 1	< 4	0.92	340	< ***0.05***	< 1	1.2	< ***0.7***	190
hardn. adj. benchm.			1000	150	0.94	177	22.24	7.85	2352	0.002	128	4.6	0.469	308
Iron Springs Willard Adit 1 discharge.	IG-13	230	***64000***	***200***	***67***	1.1	***1400***	***460***	***3600***	< ***0.05***	***43***	0.3	< ***0.7***	***13000***
hardn. adj. benchm.			1000	150	0.79	147	18.25	6.15	2177	0.002	105	4.6	0.315	253
Illinois Gulch at Illinois Gulch Road	IG-14	77	420	0.23	***0.4***	< 1	< 4	0.38	5	< ***0.05***	< 1	0.13	< ***0.7***	***100***
hardn. adj. benchm.			1000	150	0.35	60	7.16	1.89	1512	0.002	42	4.6	0.048	99
Illinois Gulch headwaters	IG-15	63	50	0.15	***1.2***	< 1	< 4	1.3	< 2	< ***0.05***	< 1	< 0.17	< ***0.7***	***250***
hardn. adj. benchm.			1000	150	0.30	51	6.03	1.52	1414	0.002	35	4.6	0.034	84

Attachment A-3
Surface Water Hardness Adjusted Benchmark Comparison
Illinois Gulch
June 5, 2013 (High Flow)

Sample	Sample ID	Hardness	Total Iron[b]	Arsenic[a]	Cadmium[a]	Chromium[a]	Copper[a]	Lead[a]	Manganese[a]	Mercury[a]	Nickel[a]	Selenium[a]	Silver[a]	Zinc[a]
		(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Willard Adit 2 located 100 yards north of Willard Adit 1 discharge at IG-13	IG-16	190	***31000***	2.3	***9.4***	< 1	***120***	***31***	1500	< ***0.05***	28	< 0.17	< ***0.7***	***4200***
hardn. adj. benchm.			1000	150	0.68	125	15.50	5.02	2043	0.002	90	4.6	0.226	215

Notes:

- All results are reported as dissolved with the exception of iron which is reported in the total fraction.
- Benchmarks are hardness adjusted for Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn
- Bold values indicate exceedance of hardness - adjusted benchmark.
- Selenium and mercury can bioaccumulate in food chains. The benchmarks in this spreadsheet are solely for screening purposes. Other site-specific values may be more appropriate.

a: Colorado Department of Public Health and the Environment (CDPHE), 2009. Regulation no. 31 – The basic standards and methodologies for surface water (5 CCR 1002 – 31): Denver, Water Quality Control Commission, 55-56 p.

b. Iron trec standard for Illinois Gulch segment is 1,000 µg/L

< The analyte result is a Non-detect below the laboratory reporting limit

Attachment A-4
Surface Water Hardness Adjusted Benchmark Comparison
Illinois Gulch
July 17, 2013 (High Flow)

Sample	Sample ID	Hardness	Total Iron[b]	Arsenic[a]	Cadmium[a]	Chromium[a]	Copper[a]	Lead[a]	Manganese[a]	Mercury[a]	Nickel[a]	Selenium[a]	Silver[a]	Zinc[a]
		(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Illinois Gulch at Ice Arena	IG-01	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Illinois Gulch below Iron Springs Gulch confluence	IG-02	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Illinois Gulch above Iron Springs Gulch confluence	IG-03	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Illinois Gulch above Iron Springs Gulch Confluence	IG-03-01	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Gulch below Little Mountain confluence	IG-04	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Gulch above Little Mountain confluence	IG-05	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Little Mountain above Iron Springs Gulch Confluence	IG-06	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Little Mountain Spring 2 - Spring above mine influence	IG-07	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Little Mountain Spring 1 - Seep discharge	IG-08	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Gulch below Bright Hope Road	IG-09	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence	IG-10	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge	IG-11	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs mine dump Seep A	IG-12	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Willard Adit 1 discharge	IG-13	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Illinois Gulch at Illinois Gulch Road	IG-14	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Illinois Gulch headwaters	IG-15	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Willard Adit 2 located 100 yards north of Willard Adit 1 discharge at IG-13	IG-16	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Outlet of pond above Iron Springs Mine Dump	IG-17	230	740	0.43	< 0.07	< 1	< 4	0.33	190	< ***0.05***	< 1	1.7	< ***0.7***	50
hardn. adj. benchm.			1000	150	0.79	147	18.25	6.15	2177	0.002	105	4.6	0.315	253
Inlet to Pond above Iron Springs Mine Dump	IG-18	250	120	0.12	< 0.07	< 1	< 4	0.25	65	< ***0.05***	< 1	2.9	< ***0.7***	17
hardn. adj. benchm.			1000	150	0.84	157	19.60	6.72	2238	0.002	113	4.6	0.363	271
Surface Water Flow East of Bright Hope Road	IG-19	80	24	0.32	***1.9***	< 1	< 4	0.39	< 2	< ***0.05***	< 1	0.26	< ***0.7***	***160***
hardn. adj. benchm.			1000	150	0.36	62	7.40	1.97	1531	0.002	43	4.6	0.051	103

Notes:
- All results are reported as dissolved with the exception of iron which is reported in the total fraction
- Benchmarks are hardness adjusted for Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn
- Bold values indicate exceedance of hardness - adjusted benchmark
- Selenium and mercury can bioaccumulate in food chains. The benchmarks in this spreadsheet are solely for screening purposes. Other site-specific values may be more appropriate.

a: Colorado Department of Public Health and the Environment (CDPHE), 2009. Regulation no. 31 – The basic standards and methodologies for surface water (5 CCR 1002 – 31): Denver, Water Quality Control Commission, 55-56 p.

b. Iron trec standard for Illinois Gulch segment is 1,000 µg/L

< The analyte result is a Non-detect below the laboratory reporting limit

Attachment A-5
Surface Water Hardness Adjusted Benchmark Comparison
Illinois Gulch
August 28, 2013 (Low Flow)

Sample	Sample ID	Hardness (mg/L)	Total Iron[b] (µg/L)	Arsenic[a] (µg/L)	Cadmium[a] (µg/L)	Chromium[a] (µg/L)	Copper[a] (µg/L)	Lead[a] (µg/L)	Manganese[a] (µg/L)	Mercury[a] (µg/L)	Nickel[a] (µg/L)	Selenium[a] (µg/L)	Silver[a] (µg/L)	Zinc[a] (µg/L)
Illinois Gulch at Ice Arena	IG-01	130	240	0.28	***1.5***	< 1	4	0.33	230	< ***0.05***	1	< 0.17	< ***0.7***	***430***
hardn. adj. benchm.			1000	150	0.51	92	11.21	3.34	1800	0.002	65	4.6	0.118	155
Illinois Gulch below Iron Springs Gulch confluence	IG-02	120	350	0.34	***1.6***	< 1	< 4	0.34	230	< ***0.05***	1.1	< 0.17	< ***0.7***	***430***
hardn. adj. benchm.			1000	150	0.48	86	10.47	3.07	1753	0.002	61	4.6	0.103	145
Illinois Gulch above Iron Springs Gulch confluence	IG-03	98	34	0.28	***0.65***	< 1	4.1	0.37	< 2	< ***0.05***	< 1	< 0.17	< ***0.7***	86
hardn. adj. benchm.			1000	150	0.42	73	8.80	2.46	1639	0.002	51	4.6	0.073	122
Illinois Gulch above Iron Springs Gulch Confluence	IG-03-01	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Gulch below Little Mountain confluence	IG-04	150	***1800***	0.53	***3.2***	< 1	< 4	0.38	600	< ***0.05***	3.5	0.21	< ***0.7***	***990***
hardn. adj. benchm.			1000	150	0.57	103	12.66	3.90	1888	0.002	73	4.6	0.151	176
Iron Springs Gulch above Little Mountain confluence	IG-05	160	***1400***	0.36	***6***	< 1	13	0.53	940	< ***0.05***	6.7	< 0.17	< ***0.7***	***1800***
hardn. adj. benchm.			1000	150	0.60	109	13.38	4.18	1929	0.002	77	4.6	0.169	186
Little Mountain above Iron Springs Gulch Confluence	IG-06	150	***2200***	1.5	0.57	< 1	< 4	0.31	410	< ***0.05***	1.9	0.18	< ***0.7***	***560***
hardn. adj. benchm.			1000	150	0.57	103	12.66	3.90	1888	0.002	73	4.6	0.151	176
Little Mountain Spring 2 - Spring above mine influence	IG-07	100	17	0.23	***0.75***	< 1	4.3	0.28	< 2	< ***0.05***	< 1	0.2	< ***0.7***	110
hardn. adj. benchm.			1000	150	0.42	74	8.96	2.52	1650	0.002	52	4.6	0.075	124
Little Mountain Spring 1 - Seep discharge	IG-08	340	***20000***	16	0.29	< 1	< 4	5.4	***2600***	< ***0.05***	15	< 0.17	< ***0.7***	***3500***
hardn. adj. benchm.			1000	150	1.06	202	25.48	9.26	2480	0.002	146	4.6	0.616	353
Iron Springs Gulch below Bright Hope Road	IG-09	180	***1800***	0.42	***7***	< 1	***19***	1.1	1100	< ***0.05***	8.3	< 0.17	< ***0.7***	***2000***
hardn. adj. benchm.			1000	150	0.66	120	14.80	4.74	2006	0.002	86	4.6	0.206	205
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence	IG-10	210	***4600***	1.6	***18***	< 1	***130***	***130***	***2200***	< ***0.05***	19	< 0.17	< ***0.7***	***4800***
hardn. adj. benchm.			1000	150	0.74	136	16.88	5.59	2112	0.002	97	4.6	0.269	234
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge.	IG-11	220	***7600***	1.7	***26***	< 1	***290***	***130***	***2900***	< ***0.05***	24	< 0.17	< ***0.7***	***7100***
hardn. adj. benchm.			1000	150	0.76	141	17.57	5.87	2145	0.002	101	4.6	0.291	243
Iron Springs mine dump Seep A	IG-12	230	810	2.5	< 0.07	< 1	< 4	0.46	98	< ***0.05***	< 1	1.4	< ***0.7***	< 10
hardn. adj. benchm.			1000	150	0.79	147	18.25	6.15	2177	0.002	105	4.6	0.315	253
Iron Springs Willard Adit 1 discharge	IG-13	200	***16000***	6.1	***26***	< 1	***180***	***190***	***2400***	< ***0.05***	21	< 0.17	< ***0.7***	***5900***
hardn. adj. benchm.			1000	150	0.71	131	16.19	5.31	2078	0.002	93	4.6	0.247	224
Illinois Gulch at Illinois Gulch Road	IG-14	95	76	0.22	0.36	< 1	< 4	0.21	16	< ***0.05***	< 1	< 0.17	< ***0.7***	77
hardn. adj. benchm.			1000	150	0.41	71	8.57	2.38	1622	0.002	50	4.6	0.069	119
Illinois Gulch headwaters	IG-15	78	6.9	0.17	***0.83***	< 1	< 4	1.2	< 2	< ***0.05***	< 1	< 0.17	< ***0.7***	***180***
hardn. adj. benchm.			1000	150	0.35	60	7.24	1.92	1519	0.002	42	4.6	0.049	101
Willard Adit 2 located 100 yards north of Willard Adit 1 discharge at IG-13	IG-16	190	***16000***	2.4	***4.9***	< 1	14	***17***	1400	< ***0.05***	18	< 0.17	< ***0.7***	***2700***
hardn. adj. benchm.			1000	150	0.68	125	15.50	5.02	2043	0.002	90	4.6	0.226	215
Outlet of pond above Iron Springs Mine Dump	IG-17	260	510	0.41	< 0.07	< 1	< 4	0.21	230	< ***0.05***	< 1	1.6	< ***0.7***	< 10
hardn. adj. benchm.			1000	150	0.87	162	20.26	7.00	2268	0.002	117	4.6	0.388	281
Inlet to Pond above Iron Springs Mine Dump	IG-18	250	170	0.1	< 0.07	< 1	< 4	< 0.15	56	< ***0.05***	< 1	2.6	< ***0.7***	11
hardn. adj. benchm.			1000	150	0.84	157	19.60	6.72	2238	0.002	113	4.6	0.363	271
Surface Water Flow East of Bright Hope Road	IG-19	110	21	0.25	***2***	< 1	< 4	0.33	< 2	< ***0.05***	< 1	0.23	< ***0.7***	***180***
hardn. adj. benchm.			1000	150	0.45	80	9.72	2.79	1703	0.002	56	4.6	0.088	135

Notes:
- All results are reported as dissolved with the exception of iron which is reported in the total fraction.
- Benchmarks are hardness adjusted for Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn
- Bold values indicate exceedance of hardness - adjusted benchmark.
- Selenium and mercury can bioaccumulate in food chains. The benchmarks in this spreadsheet are solely for screening purposes. Other site-specific values may be more appropriate.

a: Colorado Department of Public Health and the Environment (CDPHE), 2009. Regulation no. 31 – The basic standards and methodologies for surface water (5 CCR 1002 – 31): Denver, Water Quality Control Commission, 55-56 p

b. Iron trec standard for Illinois Gulch segment is 1,000 µg/L

< The analyte result is a Non-detect below the laboratory reporting limit

Attachment A-6
Surface Water Hardness Adjusted Benchmark Comparison
Illinois Gulch
July 2, 2014 (High Flow)

Sample	Sample ID	Hardness	Total Iron[b]	Arsenic[a]	Cadmium[a]	Chromium[a]	Copper[a]	Lead[a]	Manganese[a]	Mercury[a]	Nickel[a]	Selenium[a]	Silver[a]	Zinc[a]
		(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Illinois Gulch at Ice Arena	IG-01	86	296	< 2	***1.74***	< 2	4.32	0.314	120	< ***0.1***	1.09	< 2	< ***1***	***357***
hardn. adj. benchm.			1000	150	0.38	66	7.87	2.13	1569	0.002	46	4.6	0.058	109
Illinois Gulch below Iron Springs Gulch confluence	IG-02	87	0	< ***406***	***1.99***	< 2	5.16	0.359	147	< ***0.1***	1.06	< 2	< ***1***	***405***
hardn. adj. benchm			1000	150	0.38	66	7.95	2.16	1575	0.002	46	4.6	0.059	110
Illinois Gulch above Iron Springs Gulch confluence	IG-03	71	< 250	< 2	***0.618***	< 2	0.896	0.321	2.25	< ***0.1***	< 1	< 2	< ***1***	92.1
hardn. adj. benchm.			1000	150	0.33	56	6.68	1.73	1472	0.002	39	4.6	0.042	93
Illinois Gulch above Iron Springs Gulch Confluence	IG-03-01	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Gulch below Little Mountain confluence	IG-04	138	***1860***	< 2	***6.73***	< 2	***14.9***	0.533	622	< ***0.1***	4.8	< 2	< ***1***	***1480***
hardn. adj. benchm.			1000	150	0.54	96	11.79	3.57	1836	0.002	68	4.6	0.131	164
Iron Springs Gulch above Little Mountain confluence	IG-05	138	***1850***	< 2	***8.69***	< 2	***19.9***	0.514	713	< ***0.1***	5.24	< 2	< ***1***	***1810***
hardn. adj. benchm.			1000	150	0.54	96	11.79	3.57	1836	0.002	68	4.6	0.131	164
Little Mountain above Iron Springs Gulch Confluence	IG-06	132	***2370***	1.72	***1.02***	< 2	0.93	0.238	578	< ***0.1***	3.03	< 2	< ***1***	***1030***
hardn. adj. benchm.			1000	150	0.52	93	11.35	3.40	1809	0.002	66	4.6	0.121	157
Little Mountain Spring 2 - Spring above mine influence	IG-07	354	21700	13.9	< 1	< 10	< 5	0.841	***3090***	***0.055***	15.8	< ***10***	< ***5***	***4720***
hardn. adj. benchm.			1000	150	1.09	209	26.38	9.65	2513	0.002	152	4.6	0.660	365
Little Mountain Spring 1 - Seep discharge	IG-08	73	< ***250***	< 2	***0.808***	< 2	1.18	0.459	7.75	< ***0.1***	< 1	< 2	< ***1***	***152***
hardn. adj. benchm.			1000	150	0.33	57	6.84	1.78	1485	0.002	40	4.6	0.044	95
Iron Springs Gulch below Bright Hope Road	IG-09	150	***2120***	< 2	***10.3***	< 2	***32.1***	0.987	824	< ***0.1***	6.44	< 2	< ***1***	***2070***
hardn. adj. benchm.			1000	150	0.57	103	12.66	3.90	1888	0.002	73	4.6	0.151	176
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence	IG-10	234	***8320***	1.17	***32.6***	< 2	***270***	***189***	***2600***	< ***0.1***	20.6	< 2	< ***1***	***7130***
hardn. adj. benchm.			1000	150	0.80	149	18.52	6.26	2190	0.002	107	4.6	0.324	257
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge	IG-11	213	***9850***	2.16	***53.1***	< 2	***557***	***210***	***3730***	< ***0.1***	28.3	1.07	< ***1***	***11200***
hardn. adj. benchm			1000	150	0.75	138	17.09	5.67	2122	0.002	99	4.6	0.276	237
Iron Springs mine dump Seep A	IG-12	279	885	0.972	< 0.2	1	1.53	0.136	69.9	< ***0.1***	< 1	3.01	< ***1***	24.3
hardn. adj. benchm.			1000	150	0.91	172	21.52	7.54	2322	0.002	124	4.6	0.439	298
Iron Springs Willard Adit 1 discharge	IG-13	222	***35000***	29.7	***52.1***	< 2	***423***	***316***	***3580***	***0.093***	27.3	< 2	< ***1***	***10200***
hardn. adj. benchm.			1000	150	0.77	142	17.70	5.93	2152	0.002	102	4.6	0.296	245
Illinois Gulch at Illinois Gulch Road	IG-14	69	< 250	< 2	***0.449***	< 2	0.866	0.262	5.31	< ***0.1***	< 1	< 2	< ***1***	***94.2***
hardn. adj. benchm			1000	150	0.32	55	6.52	1.68	1458	0.002	38	4.6	0.040	91
Illinois Gulch headwaters	IG-15	52	< 250	< 2	***0.806***	< 2	1.25	***1.87***	< 5	< ***0.1***	< 1	< 2	< ***1***	***169***
hardn. adj. benchm.			1000	150	0.26	43	5.12	1.23	1327	0.002	30	4.6	0.024	71
Willard Adit 1 located 100 yards north of Willard Adit 1 discharge at IG-13	IG-16	179	***23400***	1.94	***8.72***	< 2	***70.2***	***50.9***	1360	***0.058***	18.7	< 2	< ***1***	***3320***
hardn. adj. benchm			1000	150	0.65	119	14.73	4.71	2003	0.002	85	4.6	0.204	204
Outlet of pond above Iron Springs Mine Dump	IG-17	280	510	0.726	< 0.2	1.36	1.51	< 0.2	59.1	< ***0.1***	< 1	3.68	< ***1***	20.2
hardn. adj. benchm			1000	150	0.92	172	21.59	7.56	2324	0.002	124	4.6	0.441	299
Inlet to Pond above Iron Springs Mine Dump	IG-18	296	< 250	< 2	0.14	1.49	1.08	< 0.2	36.1	< ***0.1***	< 1	***4.61***	< ***1***	34
hardn. adj. benchm.			1000	150	0.95	180	22.64	8.02	2368	0.002	130	4.6	0.485	314
Surface Water Flow East of Bright Hope Road	IG-19	74	100	< 2	***1.72***	< 2	1.29	0.25	< 5	< ***0.1***	< 1	< 2	< ***1***	***144***
hardn. adj. benchm.			1000	150	0.34	58	6.92	1.81	1492	0.002	40	4.6	0.045	96
Mountain Pride	OP 01	128	< ***250***	< 2	***1.4***	< 2	1.29	0.465	72.3	< ***0.1***	1.82	< 2	< ***1***	***540***
hardn. adj. benchm.				150	0.51	91	11.06	3.29	1791	0.002	64	4.6	0.115	153
Mountain Pride	OP 02	52	< ***250***	< 2	***0.851***	< 2	1.45	***2.1***	< 5	< ***0.1***	< 1	< 2	< ***1***	***194***
hardn. adj. benchm				150	0.26	43	5.12	1.23	1327	0.002	30	4.6	0.024	71
Mountain Pride	OP 03	47	< ***250***	< 2	***0.374***	< 2	1.07	***2.89***	< 5	< ***0.1***	< 1	< 2	< ***1***	***68***
hardn. adj. benchm.				150	0.24	40	4.70	1.10	1283	0.002	27	4.6	0.020	65
Mountain Pride	OP 04	50	< ***250***	< 2	< 0.2	< 2	0.654	< 0.2	< 5	< ***0.1***	< 1	< 2	< ***1***	10.2
hardn. adj. benchm.				150	0.25	42	4.95	1.17	1309	0.002	29	4.6	0.023	69

Notes:
- All results are reported as dissolved with the exception of iron which is reported in the total fraction.
- Benchmarks are hardness adjusted for Cd, Cr, Cu, Pb, Mn, Ni, Ag, and Zn
- Bold values indicate exceedance of hardness - adjusted benchmark.
- Selenium and mercury can bioaccumulate in food chains. The benchmarks in this spreadsheet are solely for screening purposes. Other site-specific values may be more appropriate.

a. Colorado Department of Public Health and the Environment (CDPHE), 2009. Regulation no. 31 – The basic standards and methodologies for surface water (5 CCR 1002 – 31). Denver, Water Quality Control Commission, 55-56 p.

b. Iron trec standard for Illinois Gulch segment is 1,000 µg/L

< The analyte result is a non-detect below the laboratory reporting limit.

Attachment A-7
Surface Water Hardness Adjusted Benchmark Comparison
Illinois Gulch
September 18, 2014 (Low Flow)

Sample	Sample ID	Hardness	Total Iron[b]	Arsenic[a]	Cadmium[a]	Chromium[a]	Copper[a]	Lead[a]	Manganese[a]	Mercury[a]	Nickel[a]	Selenium[a]	Silver[a]	Zinc[a]
		(mg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Illinois Gulch at Ice Arena	IG-01	132	296	< 2	2.13	< 2	2.3	0.559	327	< 0.1	1.33	< 2	< 1	693
hardn. adj. benchm.			1000	150	0.52	93	11.35	3.40	1809	0.002	66	4.6	0.121	157
Illinois Gulch below Iron Springs Gulch confluence	IG-02	133	950	< 2	2.87	< 2	3.06	0.407	398	< 0.1	2.2	< 2	< 1	798
hardn. adj. benchm.			1000	150	0.52	94	11.43	3.43	1814	0.002	66	4.6	0.123	159
Illinois Gulch above Iron Springs Gulch confluence	IG-03	101	< 250	< 2	0.966	< 2	0.744	0.451	2.64	< 0.1	< 1	< 2	< 1	116
hardn. adj. benchm.			1000	150	0.43	75	9.03	2.54	1655	0.002	52	4.6	0.076	125
Illinois Gulch above Iron Springs Gulch Confluence	IG-03-01	--	--	--	--	--	--	--	--	--	--	--	--	--
hardn. adj. benchm.			1000											
Iron Springs Gulch below Little Mountain confluence	IG-04	147	1250	< 2	4.24	< 2	5.4	0.404	619	< 0.1	5.84	< 2	< 1	1180
hardn. adj. benchm.			1000	150	0.56	102	12.45	3.82	1875	0.002	72	4.6	0.146	173
Iron Springs Gulch above Little Mountain confluence	IG-05	151	1090	< 2	5.86	< 2	6.78	0.496	754	< 0.1	4.18	< 2	< 1	1460
hardn. adj. benchm.			1000	150	0.58	104	12.74	3.93	1892	0.002	74	4.6	0.153	177
Little Mountain above Iron Springs Gulch Confluence	IG-06	144	2060	0.993	0.698	< 2	0.738	0.128	498	< 0.1	2.2	< 2	< 1	757
hardn. adj. benchm.			1000	150	0.56	100	12.23	3.73	1863	0.002	71	4.6	0.141	170
Little Mountain Spring 2 - Spring above mine influence	IG-07	142	3120	1.69	0.729	< 2	0.735	0.253	512	< 0.1	2.05	< 2	< 1	800
hardn. adj. benchm.			1000	150	0.55	99	12.08	3.68	1854	0.002	70	4.6	0.137	168
Little Mountain Spring 1 - Seep discharge	IG-08	98	< 250	< 2	0.74	< 2	0.75	< 0.2	< 5	< 0.1	< 1	< 2	< 1	103
hardn. adj. benchm.			1000	150	0.42	73	8.80	2.46	1639	0.002	51	4.6	0.073	122
Iron Springs Gulch below Bright Hope Road	IG-09	161	1620	< 2	7.03	< 2	11.7	0.825	967	< 0.1	5.01	< 2	< 1	1880
hardn. adj. benchm.			1000	150	0.60	109	13.45	4.21	1933	0.002	78	4.6	0.170	187
Iron Springs Gulch below Willard Adit discharge and mine dump seepage confluence	IG-10	217	6920	1.78	21.6	< 2	109	133	2700	< 0.1	14.2	< 2	< 1	6310
hardn. adj. benchm.			1000	150	0.76	140	17.36	5.78	2135	0.002	100	4.6	0.285	241
Iron Springs Mine Dump Seepage above confluence with Willard Adit discharge	IG-11	204	8380	2.8	24.1	< 2	113	158	2930	< 0.1	16.6	< 2	< 1	7000
hardn. adj. benchm.			1000	150	0.72	133	16.47	5.42	2092	0.002	95	4.6	0.256	228
Iron Springs mine dump Seep A	IG-12	299	773	1.52	< 0.2	< 2	0.531	< 0.2	274	< 0.1	< 1	2.2	< 1	18.4
hardn. adj. benchm.			1000	150	0.96	182	22.83	8.10	2376	0.002	131	4.6	0.494	316
Iron Springs Willard Adit 1 discharge	IG-13	207	22200	8.99	32.4	< 2	158	257	3170	< 0.1	17.5	< 2	< 1	8150
hardn. adj. benchm.			1000	150	0.73	134	16.68	5.50	2102	0.002	96	4.6	0.262	231
Illinois Gulch at Illinois Gulch Road	IG-14	95	< 250	< 2	0.474	< 2	< 1	0.132	16.5	< 0.1	< 1	< 2	< 1	106
hardn. adj. benchm.			1000	150	0.41	71	8.57	2.38	1622	0.002	50	4.6	0.069	119
Illinois Gulch headwaters	IG-15	107	< 250	< 2	1.54	< 2	0.821	1.25	2.42	< 0.1	< 1	< 2	< 1	361
hardn. adj. benchm.			1000	150	0.44	78	9.49	2.71	1687	0.002	55	4.6	0.084	132
Willard Adit 2 located 100 yards north of Willard Adit 1 discharge at IG-13	IG-16	183	16600	2.58	5.53	< 2	14.5	50.2	1400	< 0.1	13	< 2	< 1	2730
hardn. adj. benchm.			1000	150	0.67	122	15.01	4.83	2017	0.002	87	4.6	0.212	208
Outlet of pond above Iron Springs Mine Dump	IG-17	298	773	< 2	< 0.2	< 2	0.573	< 0.2	277	< 0.1	< 1	2.45	< 1	17.6
hardn. adj. benchm.			1000	150	0.96	181	22.77	8.07	2373	0.002	131	4.6	0.491	315
Inlet to Pond above Iron Springs Mine Dump	IG-18	290	341	< 2	< 0.2	< 2	< 1	< 0.2	60.7	< 0.1	< 1	4.23	< 1	20.6
hardn. adj. benchm.			1000	150	0.94	177	22.24	7.85	2352	0.002	128	4.6	0.469	308
Surface Water Flow East of Bright Hope Road	IG-19	101	< 250	< 2	1.74	< 2	0.548	0.115	< 5	< 0.1	< 1	< 2	< 1	149
hardn. adj. benchm.			1000	150	0.43	75	9.03	2.54	1655	0.002	52	4.6	0.076	125
Mountain Pride	OP 01	155	< 250	< 2	0.57	< 2	< 1	< 0.2	51.2	< 0.1	0.652	< 2	< 1	359
hardn. adj. benchm.				150	0.59	106	13.02	4.04	1909	0.002	75	4.6	0.160	181
Mountain Pride	OP 02	79	< 250	< 2	1.11	< 2	1.04	1.91	< 5	< 0.1	< 1	2	< 1	207
hardn. adj. benchm.				150	0.35	61	7.32	1.95	1525	0.002	43	4.6	0.050	102

Notes:

- All results are reported as dissolved with the exception of iron which is reported in the total fraction
- Benchmarks are hardness adjusted for Cd, Cr, Cu, Pb, Mn, Hg, Ni, Ag, and Zn
- Bold values indicate exceedance of hardness - adjusted benchmark.
- Selenium and mercury can bioaccumulate in food chains. The benchmarks in this spreadsheet are solely for screening purposes. Other site-specific values may be more appropriate.

a: Colorado Department of Public Health and the Environment (CDPHE), 2009 Regulation no. 31 – The basic standards and methodologies for surface water (5 CCR 1002 – 31): Denver, Water Quality Control Commission, 55-56 p

b. Iron trec standard for Illinois Gulch segment is 1,000 µg/L

< The analyte result is a Non-detect below the laboratory reporting limit

Attachment B
USFS Illinois Gulch SAP and EPA TMDL Letters

SAMPLING AND ANALYSIS PLAN/QUALITY ASSURANCE PROJECT PLAN

INITIAL REMOVAL SITE INSPECTION AT ILLINOIS GULCH
BRECKENRIDGE MINING DISTRICT, SUMMIT COUNTY, COLORADO

Prepared By:

US Forest Service Region 2
Rocky Mountain Region
740 Simms Street
Golden, CO 80401

In Coordination with:
United States Environmental Protection Agency
Region 8 Ecosystem Protection and Remediation
1595 Wynkoop Street
Denver, Colorado 80202

June 2014

A. PROJECT MANAGEMENT

A.1 Title and Approval Sheet

QUALITY ASSURANCE PROJECT PLAN/SAMPLING AND ANALYSIS PLAN

ILLINOIS GULCH

JUNE 2014

Signature Page

Approvals:

Brian A Lloyd 6/10/14

Brian Lloyd — Signature/Date
U.S. Forest Service – Regional Environmental Engineering Group Leader, Rocky Mountain Region

Jean A. Wyatt 6-12-14

Jean Wyatt
U.S. Environmental Protection Agency – Project Manager/QA Delegated Official — Signature/Date

Pete Stevenson
U.S. Environmental Protection Agency – On-Scene Coordinator/QA Delegated Official — Signature/Date

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Acronym List

BGS	below ground surface
CLP	Contract Laboratory Program
COC	Chain-of-Custody
COPC	Contaminant of Potential Concern
DQA	Data Quality Assessment
DQO	Data Quality Objective
DS	Decision Statement
EDD	Electronic Data Deliverable
ESAT	Environmental Services Assistance Team
GPS	Global Positioning System
LCS	laboratory control sample
LIMS	Laboratory Information Management System
MDL	Method Detection Limit
MS/MSD	Matrix Spike/Matrix Spike Duplicate
OSC	On-Scene Coordinator
PQL	Practical Quantitation Limit
PSQ	Principal Study Question
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	Quality Control
QMP	Quality Management Plan
RPD	Relative Percent Difference
RPM	Remedial Project Manager
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
XRF	X-Ray Florescence

A.3 Distribution List

The following is a distribution list of personnel who will receive an electronic copy of the Sampling and Analysis Plan (SAP)/Quality Assurance Project Plan (QAPP) for the July 2014 sampling event at surface water and soil/waste pile sample locations located throughout Illinois Gulch. The SAP/QAPP Addendum with original signatures will be placed in the Superfund administrative record.

Table A.3-1. Distribution List

Name	Organization	Email Address
Jean Wyatt	USEPA	wyatt.jean@epa.gov
Peter Stevenson	USEPA	stevenson.peter@epa.gov
Dan Wall	USEPA	wall.dan@epa.gov
Brian Lloyd	USFS	balloyd@fs.us.gov
Steve Auer	ESAT	auer.steve@epa.gov
Allen Sorenson	DRMS	allen.sorenson@state.co.us
Stanley Feeney	CDPHE	stanley.feeney@state.co.us
Robyn Blackburn	USFWS	blackburn.robyn@epa.gov

A.4 Project/Task Organization

The following is a list of the project personnel involved in the field sampling and chemical analyses process, their respective agency/contract affiliation, and general responsibilities.

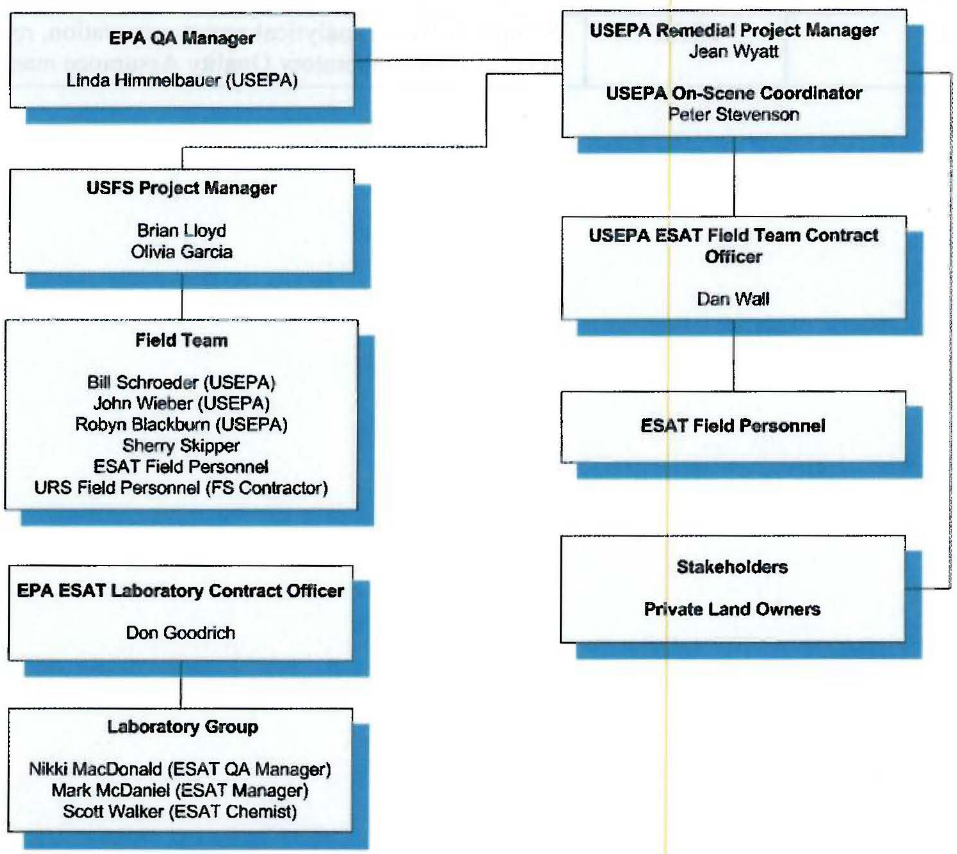
Table A.4-1. Project Personnel

Managers	Organization	Responsibilities
Jean Wyatt	USEPA	Project management; QA Reviewer, maintains copy of QA Plan
Peter Stevenson	USEPA	Removal Program Lead/On-scene Coordinator; field Lead/Oversight
Brian Lloyd/Olivia Garcia	USFS	Project management; SAP/QAPP preparation; field support
Dan Wall	USEPA	ESAT Field Contract Officer, Field Coordination
Don Goodrich	USEPA	ESAT Laboratory Contract Officer, Laboratory Coordination
		Field Team
John Wieber	USEPA	GPS, Field Documentation
Bill Schroeder	USEPA	GPS, Surface Water Sampling, Field Documentation
Skip Feeney	CDPHE	Surface Water Sampling, Field Documentation

Table A.4-1. Project Personnel

Managers	Organization	Responsibilities
Robyn Blackburn	USFWS	Surface Water Sampling, Field Documentation
Sherry Skipper	USFWS	Sample Manager
Allen Sorenson	DRMS	Mine Waste Assessment and Cleanup
USEPA Contract Personnel	ESAT/URS	XRF, GPS, Soil Sampling, Field Documentation
Laboratory Group		
Scott VanOvermeiren	ESAT	Sample analysis and analytical report preparation
Scott Walker	ESAT	Sample analysis, analytical report preparation, report review, ESAT laboratory Quality Assurance management

Organizational Chart



A.5 Problem Definition

A.5.1 Introduction

This SAP/QAPP identifies investigation activities and associated quality assurance/quality control (QA/QC) measures for a surface water and soil sampling event at historic/abandoned mine sites within the Illinois Gulch watershed located east of the City of Breckenridge in Summit County, Colorado (Figure 1). These historic mine sites are located on both USFS and private lands. The USFS, United States Environmental Protection Agency (USEPA) and local government agencies have been working cooperatively to fund, design and implement appropriate remedial measures aimed at isolating the heavy metals associated with these sources from nearby surface waters and ground waters.

This SAP/QAPP has been prepared in general accordance with the USEPA "Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4), Requirements for Quality Assurance Project Plans (QA/R-5") and the "Guidance for Quality Assurance Project Plans (EPA QA/G-5"), (U.S. Environmental Protection Agency (EPA) 2006; EPA 2001; EPA 2002). All data generated during these investigations will be collected in accordance with the quality requirements described in the QAPP for Region 8 EPA Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Removal and Emergency Response Activities in Colorado and the Environmental Services Assistance Team (ESAT) field and laboratory QAPP and Standard Operating Procedures (SOPs).

The Blue River watershed began experiencing widespread mining activity throughout the basin beginning in the 1870's. Much of the heavy metal loading throughout the Blue River basin is the result of natural geologic conditions in conjunction with historic mining activities that took place in the watershed (CDPHE 2012). Elevated concentrations of dissolved zinc and cadmium are primarily the result of historic mining activity (CDPHE 2012). Discharge from the Willard Adits is the starting point for surface water in Iron Springs Gulch, a tributary to Illinois Gulch. Surface water from Iron Springs Gulch flows a few hundred feet before mixing with water seeping from several large waste rock piles. Iron Springs Gulch flows north through a wetland before forming a channelized stream that flows into Illinois Gulch. Water Quality of Illinois Gulch continues to degrade from the confluence with Iron Springs Gulch to the confluence with the Blue River as evidenced by the increasing concentrations of zinc.

Illinois Gulch is in the Blue River Segment 12 watershed (Segment 12 -COUCBL12) and is in nonattainment of Aquatic Life Use-based water quality standards for dissolved zinc and cadmium (CDPHE 2012). Water quality in Illinois Gulch above the confluence with Iron Springs Gulch (and influence of the Willard Mine) is in attainment of assigned water quality standards. Water quality in Illinois Gulch from below the confluence with Iron Springs Gulch to the confluence with the Blue River fails to meet the Aquatic Life Use-based standards for zinc and cadmium.

Abandoned mine waste rock piles in close proximity to Illinois Gulch have been observed in the vicinity of Illinois Gulch. The mine waste piles (including Willard Mine Pile, Little Mountain Pile, Dry Gulley, Boreas Pass Road Pile, and Illinois Gulch Road Pile), and discharging mine adits (Willard Mine Adits 1 and 2), occur within the boundaries of the Arapaho National Forest, adjacent to relatively new residential housing, and occur within or immediately adjacent to wetlands.

A.5.2 Background

The Water Quality Control Division (WQCD) has a routine monitoring site (IG-01) on Illinois Gulch near the Breckenridge Ice Rink. This monitoring site provided water quality data from 2001 to 2007. In addition to routing monitoring, the WQCD conducted synoptic sampling events; two in 2008 and two in 2010. Six sites were sampled located upstream from the Willard Mine (Illinois Gulch at Illinois Gulch Road), the Willard Mine seepage, Iron Springs Gulch upstream from the confluence with Illinois Gulch, Illinois Gulch upstream of the confluence with Iron Springs Gulch, Illinois Gulch downstream of the confluence with Iron Springs Gulch, and Illinois Gulch at the Breckenridge Ice Rink (Figure 1). These data were utilized in the development of the TMDL.

TMDLs for dissolved zinc and dissolved cadmium were approved in December 2009 and May 2011 respectively. The TMDL calculated load reductions required to attain chronic dissolved zinc and cadmium standards. The reductions were calculated for high flow and low flow conditions for Illinois Gulch below the confluence with Iron Springs Gulch. During the development of the TMDLs four zinc results were recorded in 2008 on Illinois Gulch above the Iron Springs Gulch confluence. A mean hardness of 88.5 mg/L was used to calculate a chronic zinc Aquatic Life Use-based standard of 112.10, which when compared to 98.2 ug/L, the 85 % of zinc, shows attainment. Of these four sampling events, there were no exceedances of the zinc acute aquatic life standard. Six cadmium results were recorded on Illinois Gulch above the Iron Springs Gulch confluence between 2008 and 2010. All samples resulted in less than detectable levels of cadmium and were in attainment of chronic and acute Aquatic Life Use-based standards. While the portion of Illinois Gulch above the confluence with Iron Springs Gulch is attaining water quality standards, zinc concentrations are elevated (equal to about 87% of the chronic standard) for this portion. Abandoned mine waste rock piles in close proximity to Illinois Gulch have been observed in this portion.

Recent investigations by CDPHE indicate that discharge from the Willard Adits occurs in the headwaters of Iron Springs Gulch. Surface water from Iron Springs Gulch flows a few hundred feet before mixing with water seeping from large waste rock piles associated with the

Willard Mine. Iron Springs Gulch flows north through a wetland before forming a channelized stream, eventually meeting with Illinois Gulch (CDPHE 2012). The Willard Mine adits and nearby waste piles are presumed to be the most significant sources of metals to Iron Springs Gulch (CDPHE 2012).

Water quality in Illinois Gulch above the confluence with Iron Springs Gulch (and above the influence of the Willard Mine) is in attainment of assigned water quality standards. Water quality in Illinois Gulch from below the confluence with Iron Springs Gulch to the confluence with the Blue River fails to meet the Aquatic Life Use-based standards for zinc and cadmium.

Waste/soil contamination in the area has not previously been assessed, thus metals concentrations and risks associated with mine and mill waste areas are not known.

A.6 Project/Task Description

Water quality data and evaluation of the mine piles is necessary to make to determine if a removal action or other clean up action is warranted. Results from the surface water sampling will be compiled with existing data TMDL evaluation to establish baseline, document zinc and cadmium sources, measure loading contributions, and characterize sources as either natural or anthropogenic.

Figures 1 through 3 presents the study area and Tables A.6-1 and A.6-2 include the areas to be screened and sampled for waste/soil and/or surface water, respectively. Data generated from this sampling event will be used in accordance with the provisions outlined in the Data Quality Objectives (DQOs), Section A.7.

A.7 Quality Objectives and Criteria

This section discusses the DQO process and how it was applied to this study. Specific areas addressed include: the planning team and stakeholders; DQOs; and parameter metrics such as precision, accuracy, representativeness, completeness, comparability and sensitivity.

A.7.1 Planning Team and Stakeholders

The following section list the members of the DQO planning team, primary decision-makers, and parties who may be affected by the results of this study or who may use the data generated by the DQO process.

A.7.1.1 DQO Planning Team

Table A.7-1 includes the DQO planning team members, respective organizations, and affiliation with that organization.

Table A.7-1. DQO Planning Team

Name	Organization	Area of Technical Expertise
Brian Lloyd	USFS	Project Manager
Jean Wyatt	USEPA	Project Manager
Peter Stevenson	USFWS	Removal Program On-Scene Coordinator
Stanley Feeney	CDPHE	CDPHE Water Quality
Allen Sorenson	DRMS	Mine Waste Assessment and Cleanup
Robyn Blackburn	USFWS	Ecological Risk

A.7.1.2 Decision-Making Authority

The decision-makers make the final decisions based on the recommendations of the DQO planning team. The USEPA decision-maker for this project is Jean Wyatt, USEPA Region 8 Remedial Project Manager (RPM) and Peter Stevenson, On-Scene Coordinator (OSC). Brian Lloyd is the decision-maker for the USFS.

A.7.1.3 Stakeholders

Stakeholders are parties who may be affected by the results of the study and/or persons who may later use the data resulting from this DQO process. Table A.7-2 lists the impacted organizations/stakeholders and the individuals representing those organizations.

Table A.7-2. Stakeholders

Organization	Represented By
Trout Unlimited	Elizabeth Russell
USFS	Brian Lloyd
USFS	Olivia Garcia
DRMS	Allen Sorensen
USFWS	Robyn Blackburn
Private Landowners	See Tables A.6-1 and A.6-2

A.7.2 Data Quality Objectives

The DQO process specifies project decisions, the data quality required to support those decisions, specific data types needed, data collection requirements, and analytical techniques necessary to generate the specified data quality. The process also ensures that resources required to generate the data are justified. The DQO process consists of seven steps. The output from each step influences the choices to be made later in the process. These steps are as follows:

Step 1: State the problem
Step 2: Identify the goal of the study
Step 3: Identify information inputs
Step 4: Define the boundaries of the study
Step 5: Develop the analytic approach
Step 6: Specify performance or acceptance criteria
Step 7: Develop the plan for obtaining data

The first six steps of the process consist of developing decision performance criteria that will be used to develop the data collection design. The final step of the process involves developing the data collection design based on the DQOs. The following sections briefly discuss these steps and their application to the project.

A.7.2.1 Step 1: State the Problem

Water quality in Illinois Gulch from below the confluence with Iron Springs Gulch to the confluence of the Blue River fails to meet the Aquatic Life Use-based standards for zinc and cadmium. Mine waste piles and mine adit discharges are suspected to contribute metal loading to Illinois Gulch. Mine waste piles/soil have not been previously assessed, thus metal concentrations and risk associated with the mine waste areas are not known. The mine waste piles are readily accessible and are located on public lands, in private residential neighbors, and wetlands.

A.7.2.2 Step 2: Identify the Goals of the Study

The purpose of this step is to define the decision statements this study will attempt to resolve. Decision Statements are developed by combining principal study questions (PSQs) and alternative actions or estimation statements. PSQs are derived from the problem statement presented in Section A.7.2.1. For each PSQ, AAs are developed (including a no-action alternative, if appropriate) to indicate what action will be taken after each PSQ is answered.

The PSQs are as follows:

PSQ 1: Are metals concentrations in mine waste piles elevated to levels that would require further consideration for a Removal Action?

PSQ 2: What is the contribution of dissolved zinc and cadmium to Illinois Gulch from suspected sources including mine waste piles?

PSQ 3: What is the condition of water quality in an upstream/unaffected sample point located at IG-20?

Estimation Statement

Metals concentrations in mine waste/soil will be compared to established human and ecological screening benchmarks and evaluated to assess frequency and magnitude of exceedances. Historical data indicate that the largest sources of zinc and cadmium contamination are occurring within the Iron Springs Gulch and Little Mountain Spring drainages located adjacent to mine waste piles (Figure 2). Possible outcomes include: 1) metals concentrations in one or more waste/soil piles will exceed levels of concern and require consideration for Removal Action activities; 2) metals concentrations are below levels of concern and Removal Actions will not be considered; 3) water quality data will facilitate plans seeking to eliminate or reduce water quality impairments.

A.7.2.3 Step 3: Identify Information Inputs

The purpose of this step is to identify the data required to answer the PSQ listed above and to determine which inputs require environmental measurements. The required data to answer the PSQ are:

- Total and dissolved metal concentrations at sample points in Illinois Gulch, Iron Springs Gulch, and Little Mountain Spring
- Total metals concentrations in mine waste/soil
- X-Ray Fluorescence (XRF) evaluation of mine waste/soil
- Observations of residential/recreation use in the area
- Observations of habitat and potential habitat use for key receptor groups
- Collection of Global Positioning System (GPS) location data of sample locations

Table A.7-3 and A.7-4 summarize the analyte lists for the surface water and soil/waste samples, respectively. Additionally, these tables summarize the data collection activities, target analyte metals, analytical methods, sample volumes, detection and reporting limits, and holding times. Figure 1 shows the sampling areas to be included in this investigation. Figure 2 is an oversize map with the surface water sample points and Figure 3 is an oversize map illustrating the investigation areas for the soil sampling. Figure 4 shows the sampling areas included with property owner boundaries.

A.7.2.4 Step 4: Define the Boundaries of the Study

Spatial: All locations for this field activity study are located in Illinois Gulch in the vicinity of Breckenridge, Colorado. The approximate sampling locations are shown in Figures 1 through

3 and described on Tables A.6-1 and A.6-2. Tables A.6-1 and A.6-2 also include property owner information.

Temporal: Surface water is expected to vary depending on spring runoff and during undiluted low flow conditions. Therefore, surface water characterization will be completed during both high and low flow conditions in Illinois Gulch to be completed in early July and September (respectively). Metals concentrations in mine waste/soil are not expected to vary seasonally.

A.7.2.5 Step 5: Develop the Analytic Approach

Mine waste/soil analytical results from this event will be used to evaluate site conditions for determination of risks to human health and the environment, and determine if clean up actions are necessary. Risks to human health and the environment will be screened using risk screening assessment approaches developed by USEPA for use at Superfund sites (USEPA 1997). Decisions regarding the potential human health or ecological risks will be based on several lines of evidence including: concentrations of metals in waste/soil and compared to non-impacted soils, comparisons of water quality upstream and downstream of mine waste sources, observations and assumptions of site exposures, relative/representative benchmark levels of concern. Each of these lines of evidence will be combined in determining if Removal Action is necessary at one or more of the waste piles.

A.7.2.6 Step 6: Specify Performance or Acceptance Criteria

The purpose of this step is to specify the tolerable limits on decision errors, which are used to establish performance goals for the data collection design; and discuss how decision errors will be addressed. For this project, the number of samples and sampling locations are selected based on judgmental strategies that consider waste pile locations suspected to be contaminated.

Sample collection processes will be consistent with established SOPs and quality assurance (QA) procedures to minimize the potential for false positive and/or false negative errors associated with field sampling. This effort includes consistency in the way data are collected in the field and laboratory; collecting duplicate samples (and subsequent analysis using relative percent difference [RPD] statistics), and implementing a decontamination procedure (which includes using disposable sampling equipment).

Duplicate samples will be collected to determine sampling precision and the correlation between samples. According to the USEPA Contract Laboratory Program (CLP) *National Functional Guidelines for Inorganic Data Review* (USEPA, 2004), a control limit of 20% for the RPD shall be used for the original and duplicate sample values greater than or equal to 5x the CRDL. A control limit of 20% for the RPD for water samples shall be used for original and duplicate sample values. In accordance with Regional policy, the soil samples may use less restrictive criteria due to the common occurrence of laboratory variability arising from the sub-sampling of non-homogenous soil samples (USEPA 2004). Therefore, a control limit of 35% for soil for the RPD shall be used for original and duplicate sample values that are 5x the CRDL. It should be noted that these requirements are laboratory guidelines which may not apply to all field situations. Sample RPD values will be calculated using the following equation:

$$RPD = 100^* \mid \text{Sample Result} - \text{Duplicate Result} \mid /0.5 * (\text{Sample Result} + \text{Duplicate Result})$$

For laboratory analysis of samples, quality assurance/quality control (QA/QC) steps (such as using laboratory controls, matrix spikes/matrix spike duplicates [MS/MSD], blanks, etc.) will be consistent with ESAT Region 8 requirements.

A.7.2.7 Step 7: Develop a Plan to Collect the Data

Data collected from this event will assist with identifying the rank order and magnitude of contamination in waste piles and water quality in Illinois Gulch. A judgmental sampling design as described in "Guidance for Choosing a Sampling Design for Environmental Data Collection", December 2002 (USEPA QA/G-5S) will be used to assist with identification and verification of the sources of contaminants of potential concern (COPC). Specific media and analytes and criteria are discussed in Section A.7 and are summarized in Tables A.7-5 for soil samples and A.7-6 for water samples. Analytical methods for the events are described in Section B.4 and management of the data is presented in Section B.10 of this document.

A.7.2.8 Sampling Locations

Water

Surface water sample locations are described in Table A.6-1 and shown on Figures 1, 2, and 4. Information provided on Table A.6-1 includes site descriptions, coordinates, analyses, and identifies each property owner. A list of the number of samples to be collected at each site and the QAQC data collection is summarized on Table A.7-6. Twenty water samples are to be collected at sample points IG-01 through IG-20 and two duplicate samples. Surface water sample points are located above and below mine adit inputs and two sample points (IG-13 and IG-16) are collected directly from Willard Mine adit 1 and 2 discharge. A new surface water sample point (IG-20) has been added upstream from mining influence and will be designated as an upstream/unaffected sample point. This sample point is shown on Figures 1, 2, and 4. Flow discharge and field parameters including temperature, conductivity, pH, and dissolved oxygen will be measured at each sample point.

Soil

Soil sample locations will be based partially on field observations of waste material and partially on field XRF analytical results of metals in soil. Soil/waste sample locations, descriptions, and activities that will take place during July 2014 are listed in Table A.6-1 and Figure 1 shows the sampling areas to be included in this event. A list of the number of samples to be collected at each site and the QAQC data collection is summarized on Table A.7-5. A total of 49 soil samples are proposed to be collected with two duplicates. Field XRF and waste/soil selected locations selected for sample collection will be recorded and mapped using Trimble GPS hand held devices. Two locations, one east of Monroe Road and one west of Illinois Gulch Road, will be evaluated in the field with a XRF. No soil/waste samples are proposed in this area, however, if mine waste material is encountered soil samples will be collected at the discretion of the field team.

A detailed description of each sample location will be recorded in the field notebook for each site sampled. Information will consist of sample location identification number, date, time, access information, geographical observations, and other pertinent information that will be useful in identifying the sampling location in the future. In addition, a detailed description and photographic documentation of the sample location will be completed at each site.

A.7.3 Criteria, Action Limits, and Laboratory Detection Limits

Water

Table A.7-4 provides the laboratory method detection limits (MDLs), practical quantitation limits (PQLs), and available water screening hardness based benchmark values. The hardness based benchmark values are based on hardness values from previous sampling events at Illinois Gulch. MDLs and PQLs fall below available screening benchmarks with the exception of mercury with a value of 0.002. This indicates that analytical methods will be able to measure contaminant levels in the water samples with the required sensitivity.

Soil

Table A.7-3 provide the laboratory MDLs, PQLs, and available soil screening benchmarks. In every case, the MDLs and PQLs fall well below the available screening benchmarks, indicating that the analytical methods will be able to measure contaminant levels in the soil samples with the required sensitivity. It should be noted that the screening benchmarks are not considered Action Levels, but are only used to assess that laboratory detection limits will meet project goals.

1910.120. They also maintain this certification with annual eight-hour Hazardous Waste Site Operations Refresher Training, as required by Sections e and q of OSHA, 29 CFR 1910.120.

All field staff are also required to have completed the American Red Cross standard first aid and adult cardiopulmonary resuscitation (CPR) training and maintain this certification annually for adult CPR and every two years for standard first aid. The ESAT and USEPA Health and Safety Managers ensure that all field staff members complete all the training requirements prescribed by OSHA.

The training documentation for USEPA is maintained in USEPA Health and Safety records stored at Region 8 USEPA. Training documentation for other state and federal agency staff are maintained by appropriate staff at each respective agency.

A.9 Documentation and Records

The Final SAP/QAPP will be sent electronically to the individuals at email addresses identified in Section A.3. Sample locations will be recorded in field notebooks with a brief description of site name and other required information. Field log books will include detailed location-specific field documentation, as well as waste descriptions, and photographs, of each sample location will be collected at the time of data collection. The field log books will be scanned and stored electronically and presented in a trip report to be provided to USEPA and stakeholders as requested. The field notebooks, chain-of-custody forms, and other forms used for the field event will be provided to the USEPA RPM and stored at the USEPA Region 8 office.

The ESAT laboratory is required by contract to submit to USEPA an electronic and hardcopy data report containing all the analytical results for this sampling effort. The report will contain a case narrative that briefly describes the number of samples, analyses, and any analytical difficulties or QA/QC issues associated with the samples. The data report will also include signed chain-of-custody forms, analytical data, a QA/QC package, and raw data. Additional reporting requirements are outlined in the ESAT laboratory contract and quality management plan (QMP).

The documentation of the data evaluation efforts will be in the form of the work sheets prepared during validation. These worksheets will be provided by the ESAT Laboratory and provided as an appendix in the Trip Report being prepared for USEPA. The Trip Report will identify problems that may affect data usability or require that the data be qualified. The Trip Report will discuss all precision, accuracy, representativeness, completeness, comparability, and sensitivity parameter results from the data validation and overall usability of the data for project objectives.

Peer review of the data package, at a 100% frequency of reported versus raw data, will be performed by the analytical laboratory. The final report of the abbreviated data validation will be in a standard CLP format, including all laboratory and instrument QC results.

B. DATA GENERATION AND AQUISITION

This section describes data generation and acquisition activities associated with these events, including process design, sampling and analytical methods, sample handling and custody, QC, equipment, and data use and management.

B.1 Sampling Design

Sampling at this site is designed to provide characterization of mine waste and high and low flow characterization of: 1) adit and seeps discharging from mine adits; 2) surface water sampling at locations above and below significant areas of mine waste or tributaries. The high flow event is scheduled for July 2nd, the low flow event is scheduled for September 18th 2014. Samples will be transported to the laboratory immediately following collection. Sampling and analytical activities performed on site will follow all applicable USEPA SOPs as outlined below, including USEPA ERT SOP 2001 "General Field Sampling Guidelines". Sampling is anticipated to be performed in modified Level D personal protective equipment (PPE).

- USEPA Environmental Response Team General Field Sampling Guidelines SOP 2001 (August 11, 1994)
- ESAT Region 8. 2011. TechLaw Inc., Standard Operating Procedure FLD-11, "Sample Custody and Labeling,
- US Geological Survey, 1997. Sampling Strategy for the Rapid Screening of Mine-Waste Dumps on Abandoned Mine Lands.

All results will be used in order to: 1) establish baseline prior to any clean up actions as associated with the mine waste in Illinois Gulch; and, 2) correlate metals concentrations in surface water with regard to mine waste source areas and discharging mine adits and, 3) assess whether concentrations in mine waste and surface water are at levels of concern for corresponding receptor groups. The required reporting limits presented in Tables A.7-5 and A.7-6 are satisfactory for meeting risk-based screening criteria required for this project.

As indicated in Section A.6, a variety of data will be collected during these events, some of which are critical to achieve the established DQOs and project objectives, and some of which are primarily for informational purposes or which will be used to supplement critical data. The following chart specifies each data type and its purpose:

Table B.1-1. Investigation Data Type and Purpose

Data Type	Purpose
Field XRF Metals Screening	Informational
Waste/soil (analyzed for total recoverable metals and mercury)	Critical
Water (analyzed for total and dissolved metals, alkalinity, and sulfate)	Critical
GPS coordinates	Critical

Table B.1-1. Investigation Data Type and Purpose

Data Type	Purpose
Photolog	Informational
General field observations noted in logbook	Informational

B.1.1 Soil/Waste Sample Collection

This SAP/QAPP is designed to obtain initial screening assessment of soil conditions at several mine waste rock piles in Illinois Gulch. Table A.6-1 provides a description of the areas to be included in soil sample collection. Figure 3 provides an overview of the site area and the soil investigation areas.

This field event includes surface waste/soil screening and sampling. A judgmental sampling approach combined with the use of field analysis of selected metals using a hand held XRF equipment will be implemented. At each of the mine areas, systematic transects across the piles will be inspected for visual indications of mine tailings and different types/colors of mine tailings or soil. Field XRF analysis will be used to assess concentrations of arsenic, lead, and other metals present in the different types of soil, and waste/soil will be sampled at selected locations based on XRF results.

Grab samples of surface waste/soil (defined as zero to two inches below ground surface [bgs]), will be collected at selected locations distributed across each of the mine site areas (Table A.7-5). The samples may consist of waste or soil, depending on site conditions. Waste/soil samples will be collected based on field XRF screening results and other field observations. Sample descriptions, the XRF point, and the sample location will be logged in the field logbook and documented with a handheld GPS device. Results will be ultimately displayed on a site aerial photograph with XRF and laboratory results at the conclusion of the sampling event. At the discretion of the USEPA OSC, other depth-stratified grab or composite soil samples may be collected at selected locations across the site.

Mine areas to be sampled may be added if XRF screening shows elevated metals concentrations or discontinued if several locations in any direction show lead concentrations below the residential soil screening levels of 400 ppm. The number of samples and collection of waste/soil samples will be dependent upon metals concentrations identified in the field by XRF. This design will provide an estimate of the lateral range of metals concentrations on the surface layer of the pile.

B.1.2 Surface Water Data Collection

A total of 20 surface water samples will be collected as part of this event. This includes samples from Illinois Gulch, Iron Springs Gulch, two (2) draining adits that discharge into creeks, and seeps observed in the mine waste areas adjacent to Illinois Gulch. Field measurements (pH, DO, temperature, and specific conductivity) will be collected whenever enough water is present to measure these parameters in situ, and samples will be collected for laboratory analyses of total and dissolved metals, anions, and alkalinity. Water and adit locations have been previously documented with GPS and described in field log books/photo documentation. IG-20 is a new upstream/unaffected sample point that has previously not been sampled and will require documentation with GPS and photo documentation.

Surface water sampling will progress from a downstream to upstream to eliminate sediment disturbance in subsequent samples. Surface water samples will be collected by immersing sample bottle several inches beneath the water surface with the mouth of the sample bottle facing upstream. A separate surface sample may be collected if immiscible fluids are observed. To collect such a sample, the sample container will be inverted, lowered to the approximate sample depth and held at approximately a 45-degree angle with the mouth of the bottle facing downstream.

In the event a sample cannot be directly collected in the sample bottle, water will be suctioned out of the shallow water using a syringe and dedicated tubing. The syringe will be carefully inserted into the shallow water care will be taken to avoid disturbing the sediment while obtaining the sample.

B.2 Sampling Methods

This section describes XRF and surface waste/soil sampling methods that will be employed during the sampling event, and identifies as applicable SOPs, necessary equipment and support facilities. USEPA-approved SOPs will be employed during this sampling event in order to maintain consistency in sampling technique for all events being completed by various entities for this site. General Field Procedures with be conducted in accordance with the following SOPs.

- United States Environmental Response Team General Field Sampling Guidelines SOP 2001 (August 11, 1994)
- ESAT Region 8. 2011. TechLaw Inc., Standard Operating Procedure FLD-11, "Sample Custody and Labeling,
- US Geological Survey, 1997. Sampling Strategy for the Rapid Screening of Mine-Waste Dumps on Abandoned Mine Lands.

Water Sampling Methodology

Two types of water sampling will be conducted for this effort: 1) Field measurements including flow, pH, DO, temperature, and specific conductance; 2) surface water and mine adit sampling for total and dissolved metals and alkalinity and anions.

All samples will be collected using procedures and in accordance with the following SOPs:

- USEPA Environmental Response Team Surface Water SOP 2013, Rev 1.0 (December 17, 2002)
- ESAT Region 8, 2011. TechLaw Inc, Standard Operating Procedure FLD-08, "Flow Tracker Operation"
- ESAT Region 8, 2011. TechLaw Inc. Standard Operating Procedure FLD-09, Water Quality Measurements with the In-Situ® Multi-Parameter Meter

Field measurements include the use of the Hydrolab multi-probe (or similar equipment) to measure and record pH, temperature, DO, and specific conductance at all adit and surface water locations (Table A.6-2). Field instrument calibration and field parameters will be collected in accordance with manufacturers operating manual and ESAT SOPs listed above.

Flow measurements will be obtained using various widths of cutthroat flumes and flow meter in accordance with ESAT Region 8, 2011. TechLaw Inc, Standard Operating Procedure FLD-08, "Flow Tracker Operation. It is likely that flow measurements will be collected at all surface water and mine adit discharge locations; however, a final determination of flow locations will be made by the USEPA representative in the field.

Measures have been taken to minimize the amount of in-field equipment decontamination required for the sampling events. All bottles and containers will be factory sealed and certified clean prior to the sample events. Equipment such as filters and syringes, bottles, etc. will not be reused, and no decontamination will be required in the field, with the exception of field meter probes.

Appropriate quality assurance/quality control (QA/QC) samples will be collected as described in shown on Table A.7-6.

<u>XRF/Soil/Waste Sampling</u>

Waste/soil will be analyzed for metals concentrations by X-ray Fluorescence (XRF) by the USEPA ESAT contractor following the protocols outlined in the ESAT SOP#FLD-13.00. The field XRF data will only be used to identify the waste/soil locations that will be selected for sample collection for laboratory analyses of total metals and mercury. Locations to be sampled and submitted for laboratory analyses will be based on field XRF results that indicate elevated concentrations of arsenic and lead, but also include several representative low and medium XRF results to verify the accuracy of the field measurements.

The XRF technician will assess waste/soil moisture content. If the technician determines that moisture is greater than 25%, then a determination of whether the XRF will be used for screening purposes. If XRF is not used for screening, waste/soil locations will be selected at representative locations across each pile based on visual observations. Soil moisture will be estimated in the field based on feel and appearance using the following guidance:

Table B.2-1. Guidance for Soil Descriptions

Soil Moisture Percent	Coarse Texture	Moderately Coarse Texture	Medium Texture	Fine Texture
Soil Texture	Fine Sand and Loamy Fine Sand	Sandy Loam and Fine Sandy Loam	Sandy Clay Loam, Loam, and Silt Loam	Clay, Clay Loam, or Silty Clay Loam
0 to 25	Dry, loose, will hold together if not disturbed, loose sand grains on fingers with applied pressure.	Dry, forms a very weak ball, aggregated soil grains break away easily from ball.	Dry. Soil aggregations break away easily. No moisture staining on fingers, clods crumble with applied pressure.	Dry, soil aggregations easily separate, clods are hard to crumble with applied pressure

Depending on arsenic, lead, or other metals concentrations, and at the direction of the USEPA OSC, a grab waste/soil sample will be collected for each type of material or depending on the distribution and area of the metals concentrations. The grab sample will be collected representing the zero to 2-inch bgs using dedicated, sealed, plastic scoops. Grab samples will collected in accordance with ESAT Soil Sampling SOP#FLD-5. Samples will be placed directly into sample jars and marked with date, unique sample identification, sample collection time, sample depth, and sampler initials. Samples will be analyzed for the parameters listed in Tables A.7-3. In addition, requirements for the sample container, volume, preservation, and QC samples are presented in Table A.7-5: Soil Sampling and Analysis Summary.

If split samples are required, a waste/soil grab sample will be collected from zero to 2 inch bgs using a dedicated/new scoop or decontaminated stainless steel scoop and placed into a stainless steel bowl and homogenized. The homogenized sample will be transferred into two separate jars by alternating aliquots of soil into the two jars.

B.2.2 GPS Data Collection

A GPS point will be collected at each XRF and waste/soil sample location. Sample locations that have not been previously recorded will be documented following the *"Standard Operating Procedure for Global Positioning System (GPS) – Trimble GeoXT 2008 series"* FLD-07 ESAT

Region 8 and given an appropriate sample designation that is consistent with sampling location nomenclature for the site.

B.2.3 Equipment Decontamination

Disposable sampling equipment will be used for soil sampling to avoid cross contamination and the need for decontamination protocols on most equipment during this field event. The hand auger, stainless steel scoop, and stainless steel bowl will be decontaminated between locations with a brush to remove gross particulate and a distilled water rinse. Decontamination protocols as outlined in Environmental Services Assistance Team (2012) *General Field Sampling Protocols*. SOP# FLD-12, will be followed. A decon station consisting of alconox soap and tap water, followed by a triple rinse using distilled water will be used.

B.2.4 Summary of Equipment and Support Facilities

The specific equipment that will be needed in order to conduct the soil sampling field activities described in this plan are included in Table B.2-2. The support facilities that will be available during field activities will be government four-wheel drive sampling vehicles.

B.3 Sample Handling and Custody

A sample is under a person's custody if it is in their actual possession. A sample in a designated and secure area is under the custody of the person responsible for the security of that area. Sample custody is critical to ensuring the integrity of field sampling and laboratory analysis. In the field, all sample labeling, packing, transportation, and Chain of Custody (COC) procedures will follow strict sample handling protocol. All field activities must be documented. Laboratory receipt of samples, proper storage and preservation, holding times, and extraction of samples (if necessary) must also be documented.

A COC record will be completed for each shipment of samples to track the movement of samples to provide a written record of persons handling the samples and specify sample analyses. A COC record will accompany the field samples during shipment to and at through the laboratory. The information provided on the COC record will include the following:

- Project name
- Signature of the samplers
- Sampling station number or sample number
- Date and time of collection
- Grab or composite designation
- Signature of individuals involved in the sample transfer
- Time and date of sample receipt
- Type of matrix
- Preservatives used

- Sample analysis methods required

COC records initiated in the field will be placed in a plastic bag and taped to the inside of the lid of the shipping containers used for sample transport from the field to the laboratory. Each sample will be logged into the laboratory system by assigning it a unique sample number. This laboratory number and the field sample identification number will be recorded on the laboratory report. Samples will be stored and analyzed according to specified methods. The Laboratory Project Coordinator or designee will provide the contractor Project Chemist with a report upon receipt of samples which includes, at a minimum, laboratory sample identification numbers, field identification numbers, condition of samples upon receipt and the projected date of completion of the specified analyses.

<u>Water</u>

With the exception of IG-20, all surface water sample locations have previously been documented with a GPS. The surface water sample points are shown on Figures 1 and 2 and described on Table A.6-2. All surface water sample points have been designated using unique sample identifications for each location consisting of a series of letters and numbers indicating the site name and sample location. Surface water sample locations will be labeled as follows:

- IG – Illinois Gulch followed by sub locations 01 through 20.

All samples will be preserved as indicated on Table A.7-4.

<u>Soil</u>

All sample locations will be documented following the *"Standard Operating Procedure for Global Positioning System (GPS) – Trimble GeoXT 2008 series"* FLD-07 ESAT Region 8 and given an appropriate sample designation that is consistent with sampling location nomenclature for the site.

All waste/soil samples will be designated using a unique sample designation for each location and will consist of a series of letters and numbers to indicate the site name, the sample location name, and the sample media type. Newly established waste/soil sample locations will be labeled as follows:

- IL - Illinois Gulch followed by sub-locations:
  - IL-DG Dry Gulley
  - IL-BP Boreas Pass Road Pile
  - IL-IG Illinois Gulch Road Pile
  - IL-WS Former Wakefield Sawmill
  - IL-WM Willard Mine Pile

- IL-LM Little Mountain Pile

All samples will be preserved as indicated on Table A.7-3.

B.3.1 Field Documentation

All field measurements and observations will be recorded in a bound log book by the field personnel at the time they are performed in accordance with the Contract Laboratory Program Guidance for Field Samplers (EPA 2011). The personnel doing the recording will initial and date all measurements, observations, and any other notations made. Corrections will be performed by drawing a single line through the error accompanied by the date and the initials of the person performing the correction, followed by the proper entry. Chain-of-custody forms will be filled out during the time of collection and will follow protocol provided in *Sample Custody and Labeling* SOP FLD-11 (ESAT, 2012).

B.3.2 Sample Preservation

Soil/waste samples will be immediately stored in coolers on ice and kept at or below 4°C and then transported to the USEPA Region 8 Laboratory in accordance with *Standard Operating Procedure for General Field Sampling Protocols* FLD-12 (ESAT, 2011b). The maximum holdings time is 180 days for all metals, except for mercury which has a holding time of 28 days.

Surface water samples will be preserved in the field with HNO_3 and stored in coolers on ice and kept at or below 4°C and then transported to the USEPA Region 8 Laboratory in accordance with *Standard Operating Procedure for General Field Sampling Protocols* FLD-12 (ESAT, 2011b). The maximum holding time is 6 months for metals and the minimum is 14 days for alkalinity.

B.4 Analytical Methods

All samples will be submitted to the USEPA Region 8 ESAT Laboratory at USEPA Region 8 Laboratory in Golden, CO. Table B.4-1 provides the analytical protocols for the scheduled analyses for each media.

<u>Water</u>

A total of 20 samples (not including QA/QC samples) will be analyzed for dissolved and total metals, alkalinity and anions at 20 sample locations. Table A.7-6 indicates the specific analyses to be performed on each sample.

Flow and field parameters will also be measured at the 20 surface water and adit locations. Samples will be sent to the USEPA Region 8 ESAT Laboratory at USEPA Region 8 Laboratory in Golden, CO, for the following analyses:

- Total Metals (Method 200.7/200.8)
- Dissolved Metals (Method 200.7/200.8)
- Alkalinity and Anions (Method 300.0, 310.1)
- Hardness (Calculated - Method 200.7)

Soil

Depending on sample type, the samples will be analyzed for total recoverable metals, dissolved metals, hardness (calculated from dissolved metals) and mercury. Table B.4-1 includes the laboratory analytical instrumentation and methods to be used for sample analysis. These methods will be in accordance with USEPA *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, also known as SW-846, Method 7473, Revision 0, January 1998. Additionally, sample analysis will be in accordance with Method 200.7 *Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry*, Revision 4.4, May 1994, and Method 200.8 *Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry*, Revision 5.4, May 1994 and Method 245.1, Revision 3.0 *Determination of Mercury in Water by Cold Vapor Atomic Absorption Spectrometry*. Laboratory QC and performance criteria for ESAT and USEPA Region 8 are discussed in Section B.5. The sample selection for laboratory QC will be determined by the laboratory staff following the laboratory's QMP located at the laboratory in Golden, Colorado.

Sample disposal of potentially hazardous waste will follow protocol defined in *Collection, Analysis and Disposal of ESAT Laboratory Waste* SOP LAB-01.01 (ESAT, 2012).

B.5 Quality Control

B.5.1 Field Quality Control

Sample bottles will be purchased commercially, will meet USEPA specifications, and will be part of the quality control program. The sample containers to be used for this sampling project are shown on Tables A.7-3 and A.7-4 as designated for each media and analyte type.

The following types of samples will be provided for QA/QC purposes:

- One duplicate water matrix sample will be collected per 20 samples shipped to determine accuracy and precision in laboratory analytical procedures and sample collection procedures.
- One triple volume sample per 20 water samples will be collected to provide MS/MSD to allow for a check of laboratory quality control procedures.
- No rinsate or filter blanks will be taken, as all sampling equipment is pre-cleaned, sealed, and one-use disposable.

Field duplicates will be submitted with separate sample ID's. Every effort will be made to satisfy the need for completeness when implementing this SAP. Access to field sampling locations is not expected to be problematic and the ability to achieve 100% completeness is anticipated. However, in the event sampling locations are deemed inaccessible (due to physical site characteristics, biological hazards, or weather conditions), alternate sampling locations may be selected by the USEPA project manager or their technical advisors. If a location is not sampled, the reason will be documented and reported.

B.5.2 Laboratory Quality Control

Tables B.5-1 and B.5-2 provide acceptable laboratory QC criteria for the soil/waste samples. This information includes the QC checks, the run frequency, the acceptance criteria, and the corrective action. In addition, Table B.5-2 provides the calculations used for generating QA/QC parameters. The sample selection for laboratory QC will be determined by the laboratory staff following the laboratory's QMP located at the laboratory in Golden, Colorado.

The laboratory controls quality primarily through the batching process, where QC samples are run periodically or at minimum frequencies. Frequency and acceptance requirements of the QC sample results are defined within the specific analytical method SOPs. The sample selection for laboratory QC will be determined by the laboratory staff, and will depend on the sample volumes provided (i.e., in the event samples are provided with limited volume, those samples will more than likely not be used for QC Verification).

The testing and maintenance procedures of laboratory instrumentation are included in SOPs maintained at each analytical laboratory. Equipment maintenance is performed in accordance with the manufacturer's recommendations and per the requirements of the individual laboratories.

B.6 Instrument/Equipment Testing, Inspection, and Maintenance

The following chart includes the equipment that will be used during execution of this SAP that requires testing, inspection and/or maintenance.

Table B.6-1. Equipment Requiring Testing, Inspection, and/or Maintenance

Equipment/Instrument	Requirement	Schedule
Trimble® GeoXT™ GPS	Service	As needed depending on equipment Performance
Laboratory analytical Instrumentation	Calibration, routine maintenance, scheduled service	In accordance with manufacturer's specifications, user's manual and applicable SOPs

Periodic maintenance and servicing schedules as well as applicable testing criteria are included in the applicable user's manuals as well as SOPs. Note that most spare parts for each piece of equipment are kept at the Region 8 Laboratory, including parts for field equipment as well as laboratory instrumentation. Spare parts are routinely available and are ordered during periodic maintenance activities to ensure they are on hand when needed. Services agreements are in place for all laboratory instrumentation to address equipment maintenance, service, parts and repair needs as they arise. Equipment and instrument calibration requirements and frequencies are detailed in the applicable SOPs and user's manuals.

Field equipment will be inspected, tested and routine maintenance performed prior to deployment in the field by contractor staff members at the Region 8 Laboratory knowledgeable of equipment operation and maintenance requirements. Any equipment deficiencies and or maintenance requirements will be identified and mitigated (i.e., parts replaced, alternate equipment deployed, etc.). After mitigation, equipment will be re-inspected and the effectiveness of any repairs will be verified. Any repair and/or maintenance activities performed will be documented in the applicable equipment/instrument log book. Back-up equipment will be deployed during these events in case of equipment/instrument failure in the field.

B.7 Instrument/Equipment Calibration and Frequency

As indicated in Section B.6, some laboratory instrumentation (analytical instrumentation) and field equipment (such as water quality meters and flow meters) will require periodic calibration to verify function. Calibration requirements, procedures, testing criteria and deficiency resolution procedures are included in applicable SOPs and user's manuals. SOPs and user's manuals for laboratory analytical instrumentation are on file and readily available at the Region 8 Laboratory. Any variations or inability to calibrate a piece of equipment or instrument will be noted in the relevant logbook, and appropriate mitigation procedures will be followed, or replacement equipment will be obtained. Recalibration of any instrument that requires mitigation of a deficiency will be performed prior to use or deployment.

The calibration procedures for the field measurements to be performed using the *in-situ* Multi-Parameter Meter are detailed in the *Setup, Calibration, Maintenance, and Use of the In-Situ Multi-parameter Meter* SOP# FLD-9. If other Multi-probes are used for this sampling event, the field sampling team will calibrate the probe according to the manufacturer's specifications listed in the owner's manual. The SOPs and procedures appended to this document also detail the associated QA and/or QC criteria for the field analyses and equipment.

B.8 Inspection/Acceptance for Supplies and Consumables

All supplies for this event will be purchased by the USEPA from approved vendors, and stored in the field sampling room (or adjacent storage rooms at the Region 8 Laboratory). The week before the sampling event, ESAT sampling team member will gather needed supplies and consumables, which will subsequently be verified by an appropriate team member. Supplies and consumables will be ordered, inspected upon receipt, accepted, tracked, and inventoried by the USEPA field biologist at the Region 8 Laboratory. Acceptance of supplies and consumables will be based on the requirements of the end user.

B.9 Use of Existing Data (Non-Direct Measurements)

Non-direct measurements were used to prepare for project implementation. These measurements include historical reports developed by USEPA contractors and other state and federal agencies. These data were used to generate verify or identify sample locations, identify chemicals of potential ecological concern, or to identify data gaps. Historical studies associated with the Animas River provide information on expected field conditions and general contaminant concentrations, and species expected to be present. All non-direct measurements were used as qualified in previous reports. Historical data that were considered questionable or unusable by other agencies were not consideration during development of this SAP.

B.10 Data Management

Specific management processes will be followed for data likely to be collected during field activities: field equipment calibration and maintenance entries, field logbook entries, chain-of-custody forms, electronically entered/logged data (such as GPS locations, flow measurements, etc.), and analytical data.

Field equipment calibration and maintenance logs – All field equipment calibration and maintenance activities will be documented in a logbook dedicated to each piece of equipment. Logbook entries will be signed and dated by the individual performing calibration or maintenance, or the individual responsible for coordination (such as the field task lead) if equipment is shipped to a manufacturer for repair and/or maintenance. Field logbooks will be stored with the appropriate piece of equipment. When new logbooks are needed, the former logbook will be stored at the Region 8 USEPA Laboratory, Suite A127 until relinquished to USEPA in accordance with ESAT Region 8 contract requirements.

Field logbook/datasheet entries – All field measurements and observations will be recorded in a bound notebook or on appropriate data sheets by the field personnel at the time they are performed. The personnel doing the recording will initial and date each logbook. Corrections to logbook entries will be made by drawing a single line through the error accompanied by the date and the initials of the person performing the correction, followed by the proper entry. Upon return to the Region 8 laboratory, all data hand entered into field notebooks and/or datasheets will be transferred to electronic spreadsheets (such as Microsoft® Excel) by ESAT contract staff to prepare for uploading to a SCRIBE project (see below) ESAT field personnel will perform a 100% verification of spreadsheet entries against hand-entered field logbook/datasheet entries before uploading to SCRIBE. Original field notebooks and data sheets will be stored with the USEPA RPM at the Region 8 USEPA Regional Office and filed in the USEPA Region 8 Records Center upon project completion. Any non-SCRIBE electronic files generated as a part of this process (i.e., spreadsheets) will be stored on the USEPA Region 8 I drive or as otherwise requested by the RPM.

Chain-of-custody forms – When possible, chain-of-custody forms will be generated prior to field activities using SCRIBE and will be filled out when samples are collected following the protocol outlined in "*Sample Custody and Labeling*" SOP #FLD-11 (ESAT 2012). Otherwise, blank chain-of-custody forms will be used to collect sample information during field activities. Information entered on the forms during investigation activities will be entered into SCRIBE after returning to the Region 8 Laboratory as a part of the SCRIBE upload process (see below). ESAT personnel will verify 100% of all the data entered into SCRIBE against the chain-of-custody forms completed in the field. Hard copies of these forms will be stored at the Region 8 Laboratory, Suite A127 until relinquished to USEPA in accordance with ESAT Region 8 contract requirements.

Electronically entered or logged data – In some cases data may be recorded in the field directly on electronic field forms or using data loggers (such as GPS instrumentation or multi-probe data loggers). In these cases, upon return to the Region 8 Laboratory, all electronic data logs will be downloaded directly to a spreadsheet (or alternate electronic media depending on specific instrument software requirements), verified against any hand-written documentation (such as field logs and/or field data sheets) and processed into an electronic form that can be uploaded directly to SCRIBE. Similarly, electronic field forms will be processed in order to allow for upload to SCRIBE. Electronic field forms and/or data logs will be transferred to and maintained on the ESAT Region 8 contractor G drive. In cases where information must be manually entered into SCRIBE, ESAT personnel will perform 100% verification between electronic documents and/or data logs and data manually entered into SCRIBE.

Analytical Data – An analytical chemist will log all the samples into Laboratory Information Management System (LIMS) upon receipt at the Region 8 Laboratory. All analytical results will be uploaded into the LIMS in accordance with SOP# LAB-05.02 *Sample Receipt, Custody, Storage and LIMS Entry of Samples* (ESAT, 2012). Peer review of the data package, at a 100% frequency of reported versus raw data, will be performed by the analytical laboratory before a final report is released. The final report will be in a standard Contract Laboratory Program format, including all laboratory and instrument QC results. The laboratory electronic data deliverable will immediately be uploaded into a SCRIBE project for permanent electronic storage/archiving after the final report is generated. Hard copies of data reports (including bench sheets) will be stored at the Region 8 Laboratory, Suite A127 until relinquished to USEPA in accordance with ESAT Region 8 contract requirements.

SCRIBE project generation – As indicated above, all data generated as a part of field investigation activities will be uploaded into a SCRIBE project (or update to a SCRIBE project) and subsequently published to Scribe.net in accordance with the *"SCRIBE Data Loading"* SOP# DAT-1 (ESAT, 2013). It is anticipated that more data may be collected in the field that supersedes existing or historical data that has already been published (such as GPS locations, etc.) for a specific site. Therefore, before data are published or updated to SCRIBE projects, ESAT personnel will perform a 100% verification of each SCRIBE project against data collected in the field (hand entered logbook data, electronic forms and/or data logs) prior to publishing the project on Scribe.net. Verified SCRIBE projects will be published within one week of delivery of analytical electronic data delivery (EDD), when possible. The USEPA project manager will be immediately notified and an alternate publication date will be established. In the event that conditions preclude publication within that time period.

C. ASSESSMENT AND OVERSIGHT

C.1 Assessment and Response Actions

The USEPA RPM or OSC, or his/her designee, will be responsible for directing corrective actions if problems are encountered in the field which would impact the way this SAP/QAPP is implemented, or if sampling locations are inaccessible. Any problems encountered and actions taken or deviations from this SAP/QAPP will be documented in the field notebook.

C.1.1 Field Sampling Assessments

Assessment and oversight of field sampling activities and implementation of the SAP/QAPP will include the following:

- Oversight of field sampling activities
- Oversight of sample handling and chain of custody procedures

The following individuals or their designees are authorized to perform the assessments listed above:

- USEPA RPM – Jean Wyatt
- USEPA OSC – Peter Stevenson

Assessment of field activities may occur at any time and without prior notice, and will be documented in the field logbook as well as the sampling activities report. At a minimum, one assessment will occur per day and follow-up assessments may occur if potential issues are identified. Only authorized individuals may conduct the assessments and it is their role to issue any corrective action or response action to the situation. Minor problems will be addressed on site prior to resuming work. Significant problems may result in a stop work order issued by the TOPO until the project manager or designee can resolve the problem.

C.1.2 Laboratory Assessments

System assessments of the designated laboratory may be performed by ESAT. The quality assurance officer (QAO), or a designee, may perform a laboratory inspection.

Routine assessments will be conducted at least once a year, in accordance with ESAT's QMP. However, the frequency of the laboratory system assessments will also be based on the level of use and performance of individual designated laboratories. A member of the ESAT team will perform the assessment in accordance with the assessment checklist and TechLaw SOP 02-06-05. The checklist requires examining the laboratory documentation on sample receiving, sample log-in, sample storage, chain-of-custody procedures, sample preparation and analysis, instrument operating records, etc. Routine assessments will also be performed before a laboratory is added to the approved laboratory list. Should one-time specialty analysis be requested, the need for on-site assessments will be evaluated and discussed with USEPA before an audit.

Performance assessments will require preparing blind QC samples and submitting them along with project samples to the laboratory for analysis. The analytical results of the QC sample analyses are evaluated by the QAO to ensure that the laboratory maintains acceptable QC performance. Performance assessments may be requested by ESAT or USEPA. Performance evaluation (PE) samples will be prepared by and obtained from vendors. The QAO will designate if a PE sample shall be submitted. PE samples should be submitted if a laboratory has not recently passed an outside PE sample or as requested by USEPA.

Response Actions

Corrective action may be required at two phases corresponding to the two activities of data generation: 1) field activities (data gathering phase); and 2) laboratory activities (data analysis phase). Corrective Actions required as a result of the data analysis phase are initiated by the TechLaw QAO when analytical data are found to be outside the limits of acceptability, as specified in the laboratory SOPs.

C.1.3 Field Corrective Actions

Corrective Actions required as a result of the field data collection phase is initiated by the USEPA field team leader and may result from log reports or field assessments. QC needs to be implemented both during the development of the SAP and during sampling activities to ensure that Corrective Actions will not be required. Corrective Actions are initiated by USEPA if weaknesses or problems are uncovered as a result of field activities. The Corrective Actions will depend on the nature or severity of the problem and the level at which the problem is detected, and may include, but shall not be limited to:

- Modifications to sampling procedures
- Recalibration (or replacement) of field instruments
- Additional training of field personnel
- Reassignment of staff personnel
- Re-sampling

C.2 Reports to Management

Records will be maintained of the actual sample locations and the sample points will be accurately located on topographic maps and mine maps using the measured latitude/longitude or survey stationing. Procedures will provide documentation of changes in sample locations as they occur in the field due to unanticipated site conditions. Sample locations and sample collection procedures will be documented through the keeping of a field notebook and photographs. Upon receipt of analytical data, results will be compiled in a data summary report and used for an assessment of human and ecological impacts and metals loading analysis for determination of continued removal or no further action activities.

The results of all laboratory assessments will be submitted to the USEPA RPM and USEPA QA personnel, if requested. An external assessment of the designated laboratory may also be conducted by USEPA, at the Region's discretion.

D. DATA VALIDATION AND USABILITY

D.1 Data Review, Verification, and Validation

Abbreviated verification will be completed on 10% of the analytical results for data that is electronically uploaded directly from the analytical instrumentation into the ESAT LIMS. This review will be performed to ensure that data were produced in accordance with procedures outlined in this project plan. The following elements will be reviewed for compliance as part of the abbreviated data validation:

- Holding times
- Calibration
- Blanks
- Spikes
- Duplicates
- Laboratory control spikes
- Reporting limits
- Analyte quantification

Peer review of the data package, at a 100% frequency of reported versus raw data, will be performed by the analytical laboratory prior to releasing a final report.

Laboratory data validation and verification will begin at the sample log-in stage where a sample log-in technician or chemist will compare received samples against chain-of-custody forms and document sample condition (e.g., damage, cooler temperature). Validation and verification of data will be performed by QA/QC personnel following USEPA National Functional Guidance for Inorganic Data (USEPA 2002) in order to determine if the DQOs were met. Sample data deemed outside the expected range will be investigated, communicated to the analytical chemistry staff, flagged (if needed) and potentially re-sampled to verify or discredit the data. Data that have proven to be incorrect may be flagged, further reviewed, or invalidated. The cause of incorrect data will be investigated and appropriate response actions will be taken, including communication of any issues to the user in the data report.

D.2 Verification and Validation methods

Analytical data will be validated for 10% of the results by either the acting USEPA Region 8 Laboratory QA Officer or by a designated TechLaw, Inc. Quality Assurance officer outside of the Region 8 ESAT office. The validation will include reviewing 10% of the samples for 100% of the analytical analysis performed and reported. The following elements will be reviewed for compliance as part of the abbreviated data validation:

- Holding times
- Calibration
- Blanks
- Spikes
- Duplicates
- Laboratory Control Samples (LCSs)
- Reporting limits
- Analyte identification
- Analyte quantification
- Comparison of hardcopy results to electronic data deliverable

D.3 Reconciliation with User Requirements

If necessary, the analytical data will be qualified in order to convey the outcome of the data validation process to the end users to help them determine how the data may be applied in subsequent interpretations. The following definitions provide brief explanations of the national qualifiers assigned to results in the data review process. If additional qualifiers are needed, then a complete explanation of those other qualifiers will be included in the data review:

U	The analyte was analyzed for, but was not detected above the level of the reported sample quantitation limit.
J	The result is an estimated quantity. The associated numerical value is the approximate concentration of the analyte in the sample.
J+	The result is an estimated quantity, but the results may be biased high.
J-	The result is an estimated quantity, but the results may be biased low.
R	The data are unusable. The sample results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be presented in the sample.
UJ	The analyte was analyzed for, but was not detected. The reported quantitation limit is approximate and may be inaccurate or imprecise.

D.4 Reconciliation with DQOs

Information obtained from the field investigation will be evaluated through the data quality assessment (DQA) process to determine if the data are of adequate quality and quantity to support their intended use. The DQA process consists of five steps, as summarized below (USEPA 2006):

1) Review the project's objectives and sampling design: Review the objectives defined during the systematic planning to assure that they are still applicable. If objectives have not been deployed, specify them before evaluating the data for the projects objectives. Review the sampling design and data collection documentation for consistency with the project objectives observing any potential discrepancies.

2) Conduct a preliminary data review: Review QA reports (when possible) for the validation of data, calculate basic statistics, and generate graphs of the data. Use this information to learn about the structures of the data and identify patterns, relationships, or potential anomalies.

3) Select the statistical method: Select the appropriate procedures for summarizing and analyzing the data based on the review of the performance and acceptance criteria associated with the project objectives, the sampling design, and the preliminary data review. Identify the key underlying assumptions associated with the statistical tests.

4) Verify the assumptions of the statistical method: Evaluate whether the underlying assumptions hold, or whether departures are acceptable, given the actual data and other information about the study.

5) Draw conclusion from the data: Perform the calculations necessary to draw reasonable conclusions from the data. If the design is to be used again, evaluate the performance of the sampling design.

Uncertainty of validated data will be evaluated by the RPM, in consultation with the DEQ Site Project Officer, to determine if the DQOs were met. In the event that the DQOs were not met, they will be reviewed to determine if they are achievable and may be revised if necessary, and the data may be further evaluated to determine the impact to the project. Data usability and limitations will be evaluated and determined by the RPM.

E. REFERENCES

Colorado Department of Public Health and Environment. CDPHE. 2012. TMDL Bridge to Restoration Sampling and Analysis Plan Colorado Department of Public Health and Environment Water Quality Division 4300 Cherry Creek Drive South Denver, CO 80246 June 2012

Colorado Department of Public Health and the Environment (CDPHE), 2009. Regulation No. 31 – The basic Standards and Methodologies for Surface Water (5 CCR 1002-31):

ESAT Region 8, 2011. TechLaw Inc., Standard Operating Procedure FLD-08, "Flow Tracker Operation". USEPA Contract No. EP-W-06-033, DCN#:EP8-6-6098.

ESAT Region 8, 2011. TechLaw Inc. Standard Operating Procedure FLD-09, Water Quality Measurements with the In-Situ® Multi-Parameter Meter. USEPA Contract No. EP-W-06-033, DCN#:EP8-6-6122.

ESAT Region 8. 2011. TechLaw Inc., Standard Operating Procedure FLD-11, "Sample Custody and Labeling, Contract No. EP-W-06-033, DCN#: EP8-6-6121.

Method 200.7, Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectrometry, Revision 4.4, May 1994.

Method 200.8 Determination of Trace Elements in Waters and Wastes by Inductively Coupled Plasma- Mass Spectrometry, Revision 5.4, May 1994.

United States Environmental Protection Agency. 2011. Contract Laboratory Program Guidance for Field Samplers.

United States Environmental Protection Agency. 2006. *Data Quality Assessment: A Reviewers Guide* (USEPA QA/G-9R).

United States Environmental Protection Agency. 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process (USEPA QA/G-4S).

United States Environmental Protection Agency. 2004. USEPA Contract Laboratory Program *National Functional Guidelines for Inorganic Data Review* (USEPA 540-R-10-011).

United States Environmental Protection Agency. 2002. Guidance for Choosing a Sampling Design for Environmental Data Collection (USEPA QA/G-5S).

United States Environmental Protection Agency. 1994. Methods for the Determination of Metals in Environmental Samples, Supplement I (Series 200 Methods).

United States Environmental Protection Agency. 2006. Data Quality Assessment: A Reviewers Guide. USEPA QA/G-9R.

United States Environmental Protection Agency. 1997. Ecological Risk Assessment Guidance for Superfund (ERAGS): Process for designing and conducting ecological risk assessment. USEPA 540/R-97/006.

F. STANDARD OPERATING PROCEDURES

(SOPs are available upon request)

Environmental Services Assistance Team (2013) SCRIBE Data Loading. SOP# DAT-1

Environmental Services Assistance Team (2012) Collection, Analysis, and Disposal of ESAT Laboratory Waste. SOP# LAB 01.01

Environmental Services Assistance Team (2012) Sample Receipt, Custody, Storage and LIMS Entry of Samples SOP# LAB 05.02

Environmental Services Assistance Team (2012) Global Positioning System (GPS) – Trimble GeoXT 2008 series. SOP# FLD-7

Environmental Services Assitance Team (2011) Flow Tracker Operation. SOP# FLD-8

Environmental Services Assitance Team (2011) Water Quality Measurements with the In-Situ® Multi-Parameter Meter. SOP# FLD-9

Environmental Services Assistance Team (2012) Sample Custody and Labeling. SOP# FLD-11

Environmental Services Assistance Team (2012) General Field Sampling Protocols. SOP# FLD-12

Environmental Services Assistance Team (2007) Standard Operating Procedures for the Generation of an Analytical Data Deliverable Package. SOP# QAQ-4

U.S. EPA Environmental Response Team General Field Sampling Guidelines SOP 2001 (August 11, 1994)

USEPA Environmental Response Team Surface Water SOP 2013, Rev 1.0 (December 17, 2002)

U.S. Geological Survey, 1997. Sampling Strategy for the Rapid Screening of Mine-Waste Dumps on Abandoned Mine Lands.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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Phil Hegeman

JUL 28 2011

Ref: 8EPR-EP

Mr. Steve Gunderson
Director
Water Quality Control Division
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

Re: TMDL Approval
Illinois Gulch, COUCBL12 for cadmium (Cd)

Steve

Dear Mr. Gunderson:

We have completed our review of the total maximum daily loads (TMDLs) as submitted by your office on July 12, 2011 for the 303(d) listed waterbody Illinois Gulch (COUCBL12). In accordance with the Clean Water Act (33 U.S.C. 1251 et. seq.), we approve all aspects of the TMDLs as developed for certain pollutants in water quality limited waterbodies as described in Section 303(d)(1). Based on our review, we feel the separate TMDL elements in the Illinois Gulch TMDL document for cadmium (see enclosed table) are adequately addressed, taking into consideration seasonal variation and a margin of safety.

Thank you for submitting these TMDLs for our review and approval. If you have any questions, the most knowledgeable person on my staff is Julie Kinsey and she may be reached at (303) 312-7065.

Sincerely,

Carol L. Campbell

Carol L. Campbell
Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

Enclosures
1 - Approved TMDLs
2 - Minimum Submission Requirement Review

TOTAL MAXIMUM DAILY LOAD ASSESSMENT
ILLINOIS GULCH
COUCBL12
Cadmium

SUMMIT COUNTY, COLORADO
July 2011

<table>
<tr><th colspan="2">TMDL Summary</th></tr>
<tr><td>Waterbody Description / WBID</td><td>Mainstem of Illinois Gulch and Fredonia Gulch from their source to their confluence with the Blue River COUCBL12</td></tr>
<tr><td>Pollutants Addressed</td><td>Dissolved cadmium</td></tr>
<tr><td>Relevant Portion of Segment (as applicable)</td><td>Illinois Gulch</td></tr>
<tr><td>Use Classifications / Designation</td><td>Aquatic Life Cold 2, Recreation P, Water Supply, Agriculture</td></tr>
<tr><td>Water Quality Target</td><td>
<table>
<tr><td>Segment 12</td><td>Chronic</td><td>Acute</td></tr>
<tr><td>Cd-D</td><td>(1.101672-[ln(hardness)x(0.041838)]x $e^{0.7998[\ln(hardness0]-4.4451}$</td><td>Trout=(1.136672-[ln(hardness)x(0.041838)]) x$e^{0.9151[\ln(hardness)]-3.6236}$</td></tr>
</table>
</td></tr>
<tr><td>TMDL Goal</td><td>Attainment of Aquatic Life use classification standards for Cd.</td></tr>
</table>

EXECUTIVE SUMMARY

Blue River Segment 12, Illinois Gulch, was added the State's 303(d) list of water-quality impaired waterbodies for nonattainment of water quality standards for dissolved cadmium in 2010. Previously, Illinois Gulch had been on the State's 303(d) list for nonattainment of water quality standards for dissolved zinc. A TMDL for zinc was approved in 2010. Excess dissolved cadmium impairs the Aquatic Life Cold 2 classification for Segment 12. The high concentration of dissolved cadmium is primarily the result of mining activity in the watershed since the1880's. Illinois Gulch is located near Breckenridge in Summit County, Colorado. Water quality in Illinois Gulch above the Iron Springs Gulch (and influence of the Puzzle Mine) is in attainment of assigned standards while water quality below the mine has elevated cadmium levels. Acid mine drainage enters Illinois Gulch via Iron Springs Gulch.

Segment #	Segment Description	Portion	303(d) Listed Contaminants
Blue River Segment 12	Mainstem of Illinois Gulch and Fredonia Gulch from their source to their confluence with the Blue River	Illinois Gulch	Cd

Table 1. Segment within the Blue River watershed that appears on the 2010 303(d) list of impaired water bodies.

II. INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) requires states to periodically submit to the U.S. Environmental Protection Agency (EPA) a list of water bodies that are water-quality impaired. Water-quality limited segments are those water bodies that, for one or more assigned use classifications or standards, the classification or standard is not fully achieved. This list of water bodies is referred to as the "303(d) List". In Colorado, the agency responsible for developing the 303(d) list is the Water Quality Control Division (WQCD). The List is adopted by the Water Quality Control Commission (WQCC) as Regulation No. 93. The WQCC adopted the current 303(d) list March of 2010.

For waterbodies and streams on the 303(d) list a Total Maximum Daily Load (TMDL) is used to determine the maximum amount of a pollutant that a water body may receive and still maintain water quality standards. The TMDL is the sum of the Waste Load Allocation (WLA), which is the load from point source discharge, Load Allocation (LA) which is the load attributed to natural background and/or non-point sources, and a Margin of Safety (MOS) (Equation 1).

(Equation 1) $$TMDL=WLA+LA+MOS$$

Alternatively, a segment or pollutant may be removed from the list if the applicable standard is attained, if implementation of clean-up activities via alternate means will result in attainment of standards, if the original listing decision is shown to be in error or if the standards have been changed as the result of a Use Attainability Analysis (UAA), or other EPA approved recalculation method.

Illinois Gulch is a portion of Segment 12 (the mainstem of Illinois Gulch and Fredonia Gulch from their source to their confluence with the Blue River) and is identified on the 2010 303(d) list for exceeding the water quality standards for dissolved cadmium (Table 1) (WQCC, 2010). The impairment status for designated uses in Illinois Gulch is presented in Table 2.

Date (Cycle Year) of Current Approved 303(d) list: 2010		
WBID	**Segment Description**	**Designated Uses & Impairment Status**
COUCBL12	Mainstem of Illinois Gulch and Fredonia Gulch from their source to their confluence with the Blue River	Aquatic Life Cold 2: Impaired Recreation P: Not Impaired Water Supply: Not Impaired Agriculture: Not Impaired

Table 2. Designated uses and impairment status for Segment 12, Illinois Gulch.

During April 2006, EPA responded to a reported problem in the vicinity of Illinois Gulch. The Puzzle Mine discharged a slug of orange water which flowed through a gulch (named here as Iron Springs Gulch) through Illinois Gulch into Breckenridge. No fish kills were reported to EPA (Hayes Griswold, pers. comm., 2009). Some monitoring was conducted on Illinois Gulch, in the vicinity of the mine, and in the Blue River. However, the data were not used in this assessment. No hardness data were reported for this sampling event and metals were reported as total metals, while the standards are based on the dissolved fraction. It was suspected that an ice dam had formed at the adit, which broke loose during the spring, and released the backed-up water. This type of event has not been observed since then, although there continues to be seepage from the Puzzle Mine.

Geographical Extent

This listed portion of the Blue River Watershed is part of the Colorado River Blue River Basin, Hydrologic Unit Code (HUC) 14010002 and is located in Summit County. Deposits of gold and silver were mined in the watershed beginning in 1870s (Summit Historical Society of Summit County, *www.**summithistorical**.org*).

Illinois Gulch is part of the headwaters reach of the Blue River watershed. The drainage area of Illinois River watershed is 8.08 km^2. The elevation at the mouth of Illinois Gulch is 2932 meters. The mean annual precipitation is approximately 501.14 millimeters. As a headwaters tributary, Illinois Gulch is snowmelt dominated. Heavy metal pollution probably results from a combination of both natural and anthropogenic sources, heavily dominated by acid mine drainage from the Puzzle Mine, a non-active, historical mine site.

Illinois Gulch flows north parallel to Illinois Gulch Road, crosses Boreas Pass Road, flowing northwest where it confluences with Iron Springs Gulch. Iron Springs Gulch seems to originate as seepage near the Puzzle Mine Site, which is located in a large U-shaped curve made by Boreas Pass Road. The Iron Springs Gulch flows in a northerly direction to its confluence with Illinois Gulch. Illinois Gulch continues parallel to Boreas Pass Road, past the Breckenridge Ice Arena and eventually flows into the Blue River.

A map of the study area is shown in Figure 1. Associated sampling sites are marked on the Google Earth photo in Figure 2.

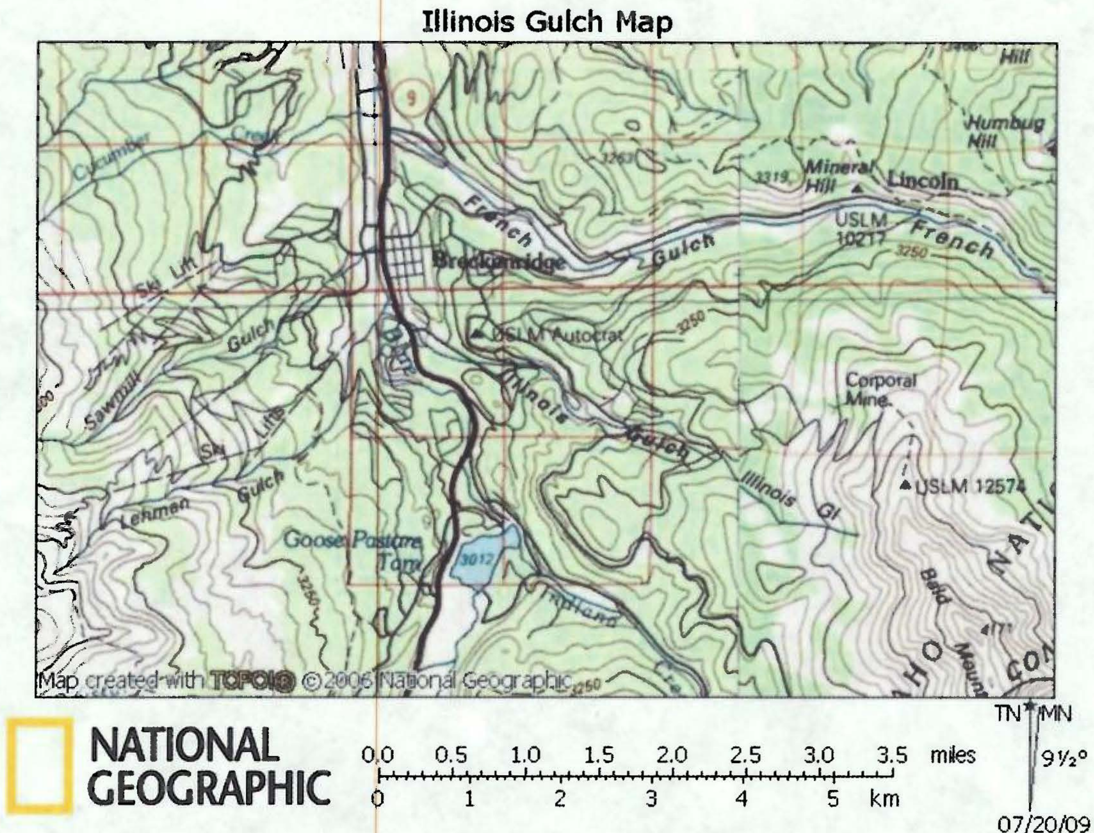

Figure 1. Illinois Gulch

Figure 2. Google Earth image of Illinois Gulch monitoring locations.

III. WATER QUALITY STANDARDS

Standards Framework

Waterbodies in Colorado are divided into discrete units or "segments". The Colorado *Basic Standards and Methodologies for Surface Water*, Regulation 31(WQCC 2011), discusses segmentation of waterbodies in terms of several broad considerations:

> *31.6(4)(b)...Segments may constitute a specified stretch of a river mainstem, a specific tributary, a specific lake or reservoir, or a generally defined grouping of waters within the basin (e.g., a specific mainstem segment and all tributaries flowing into that mainstem segment).*

(c) Segments shall generally be delineated according to the points at which the use, physical characteristics or water quality characteristics of a watercourse are determined to change significantly enough to require a change in use classifications and/or water quality standards

As noted in paragraph 31.6(4)(c), the use or uses of surface waters are an important consideration with respect to segmentation. In Colorado there are four categories of beneficial use which are recognized. These include Aquatic Life Use, Recreational Use, Agricultural Use and Water Supply Use. A segment may be designated for any or all of these "Use Classifications":

31.6 Waters shall be classified for the present beneficial uses of the water or the beneficial uses that may be reasonably expected in the future for which the water is suitable in its present condition or the beneficial uses for which it is to become suitable as a goal.

Each assigned use is associated with a series of pollutant specific numeric standards. These pollutants may vary and are relevant to a given Classified Use. Numeric pollutant criteria are identified in sections 31.11 and 31.16 of the *Basic Standards and Methodologies for Surface Water.*

Uses and Standards Addressed in this TMDL

The Colorado Basic Standards and Methodologies for Surface Water, Regulation 31 identifies standards applicable to all surface waters statewide (WQCC 2011). The pollutant of concern for this assessment is dissolved cadmium. In the case of Illinois Gulch, cadmium concentrations exceed Aquatic Life Use-based standards intended to protect against short-term, acutely toxic conditions (acute) and longer-term, sub-lethal (chronic) effects.

Chronic and acute standards are designed to protect against different ecological effects of pollutants (long term exposure to relatively lower pollutant concentrations vs. short term exposure to relatively higher pollutant concentrations). Where chronic standards are assigned, they are used because they represent a more conservative approach than the acute standards. Chronic standards represent the level of pollutants that protect 95 percent of the genera from chronic toxic effects of metals. By reducing metals concentrations to attain the chronic standard, the acute standard will also be attained. Per Regulation 31, chronic toxic effects include but are not limited to demonstrable abnormalities and adverse effects on survival, growth, or reproduction (WQCC 2011).

The specific numeric standards assigned to the listed stream segments are contained in Regulation 33, the Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12) (WQCC, 2010) (Table 3). In addition to the dissolved zinc, for which a TMDL has been approved, Illinois Gulch is 303(d) listed for dissolved cadmium (aquatic life use-based acute (trout) and chronic standards) on the 2010 303(d) list. All remaining assigned numeric standards associated with Aquatic Life, Recreational, Water Supply and Agricultural Use Classifications are attained.

Water Quality Criteria for Impaired Designated Uses		
WBID	**Impaired Designated Use**	**Applicable Water Quality Criteria and Status**
COUCBL12	Aquatic Life Cold 2	Dissolved Phase Cd (1) / Not Attained
Applicable State or Federal Regulations: (1) Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12), (Regulation No. 33)		

Table 3. Ambient water quality criteria and status for Segment 12, Illinois Gulch.

The relevant standards for the stream segment addressed in this document are Table Value Standards (TVS), which vary based on hardness. Hardness fluctuates seasonally, therefore, standards are shown for low-flow and high-flow seasons (Table 4). The low-flow season is from September through April, while the high-flow season was from May through August. Aquatic Life Use-based metals standards, identified as Table Value Standards or "TVS", are typically hardness based (arsenic, mercury and selenium are exceptions). Aquatic Life Use-based TVS for metals usually are expressed as the dissolved fraction, as opposed to the total metal fraction. Again, there are exceptions, namely aluminum, iron and, again, mercury. Cadmium standards assigned for the protection of aquatic life are expressed as the dissolved metal fraction and are hardness based. The hardness values are the average of data from all sites in the study.

Season	Hardness mg/L	Cd-D, ug/L TVS (ch)	Cd-D ug/L TVS (ac-tr)
Low-flow	130.5	0.52	2.15
High-flow	113.1	0.47	1.90

Table 4. Average hardness and table value standards (chronic and acute) for 303(d) listed segment of Illinois Gulch. Data are from the Colorado Water Quality Control Division.

IV. PROBLEM IDENTIFICATION

Much of the heavy metal loading throughout the Blue River basin is the result of natural geologic conditions and historic mining activities. The Blue River watershed began experiencing widespread mining activity throughout the basin beginning in the 1870's. Several historical mine sites are located in the vicinity of Illinois Gulch. The Puzzle Mine site is located inside of a large curve (north side of road) made by Boreas Pass Road just before Illinois Gulch Road. Commodities from the mine included gold, zinc, lead, silver, and copper. Mining operations resulted in residual levels of elevated cadmium concentrations in Illinois Gulch. Seepage from the mine site enters a gulch, named here as Iron Springs Gulch, which is tributary to Illinois Gulch. There are no permitted dischargers to Illinois Gulch.

The high metals concentrations in Illinois Gulch exceed the standards to protect aquatic life.

V. WATER-QUALITY GOAL AND TARGET

The water quality goal for the 303(d) listed segment, Illinois Gulch, is attainment of the Aquatic Life Cold 2 use classification standards for dissolved cadmium.

VI. INSTREAM CONDITIONS

Hydrology

The hydrograph of the Blue River (Figure 2) should approximate the pattern of the Illinois Gulch hydrograph, although at a larger magnitude. Such hydrographs are typical of high mountain streams, with low flows occurring in the late fall to early spring followed by a large increase in flow, usually in May or June, due to snowmelt that tails off through the summer (Figure 3, Table 5).

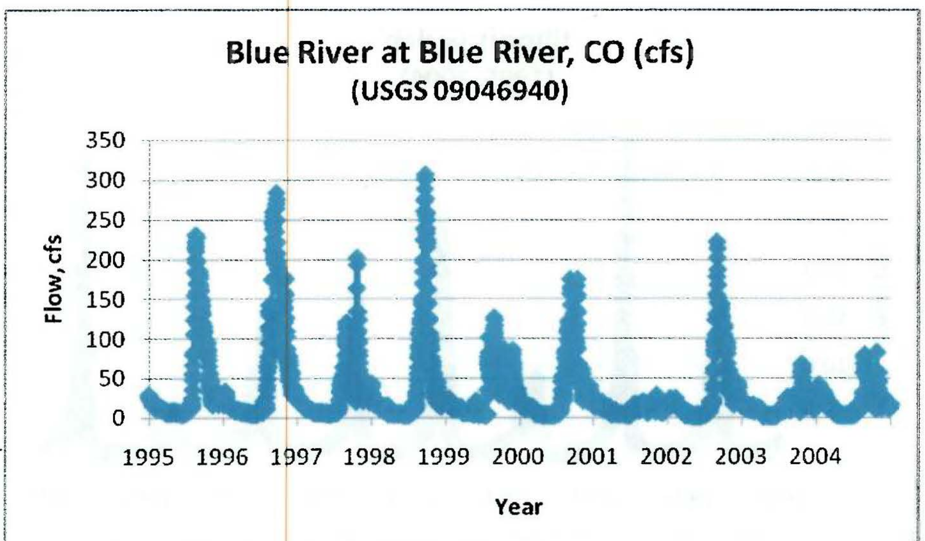

Figure 2. Hydrograph of Blue River at Blue River, CO, USGS gage 09046940.

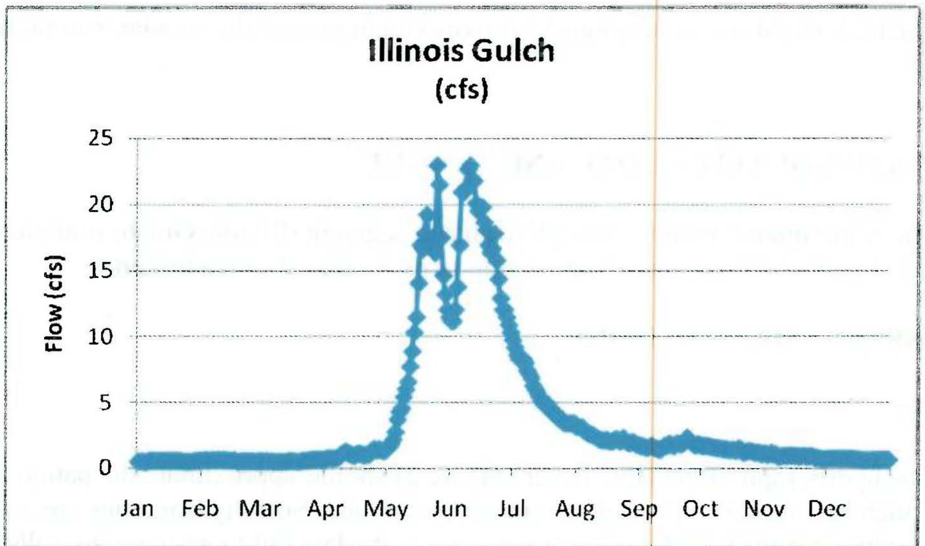

Figure 3. Annual hydrograph for Illinois Gulch

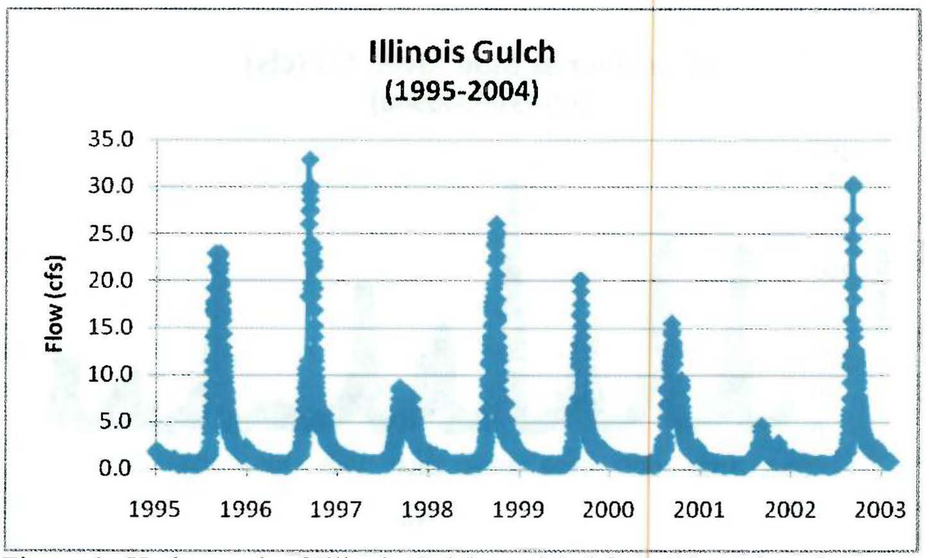

Figure 4. Hydrograph of Illinois Gulch modeled from Blue River data.

	Monthly Median. Flow Illinois Gulch. (cfs)
Jan	0.36
Feb	0.30
Mar	0.29
Apr	0.57
May	3.46
Jun	7.43
Jul	4.12
Aug	2.13
Sep	1.47
Oct	1.25
Nov	0.96
Dec	0.74

Table 5. Estimated monthly median flows (cfs), for Illinois Gulch.

Flows for the Blue River were obtained from USGS gage #09046940 near Blue River, Colorado. Illinois Gulch flows were estimated using a watershed area ratio (0.074) and applying the ratio to the data from the Blue River gage (Figure 4). Median monthly flows in the Blue River were between four and one hundred eleven cubic feet per second (cfs) based on instantaneous and estimated flows. Estimated median monthly flows for Illinois Gulch were between 0.3 and 8 cfs (Table 5).

The distribution of flows for Illinois Gulch throughout the annual cycle is illustrated in a "box and whiskers" plot (Figure 3). The boxes show the 25th and 75th percentiles, while the bars or whiskers show the 5th and 95th percentiles for the flow estimates. Medians are shown as markers in the boxes. The period of record from 1995 through 2010 was used. Higher flows are observed during May through August. Figure 4 illustrates the distribution of flows comparing the high-flow season (May through August) with low flow (September through April). Median flows for high-flow and low-flow conditions were 3.53 cfs and 0.72 cfs, respectively.

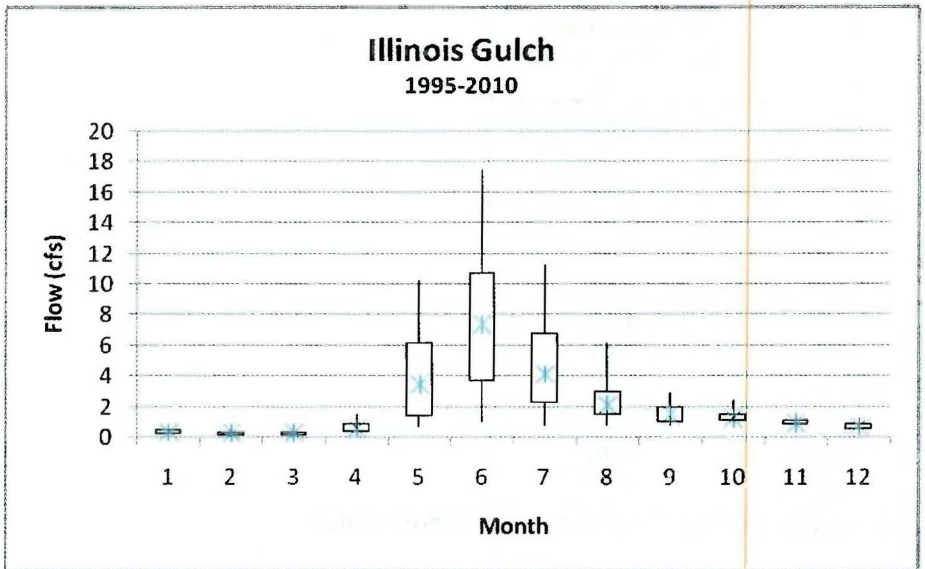

Figure 3. Distribution of flows in Illinois Gulch (by month)

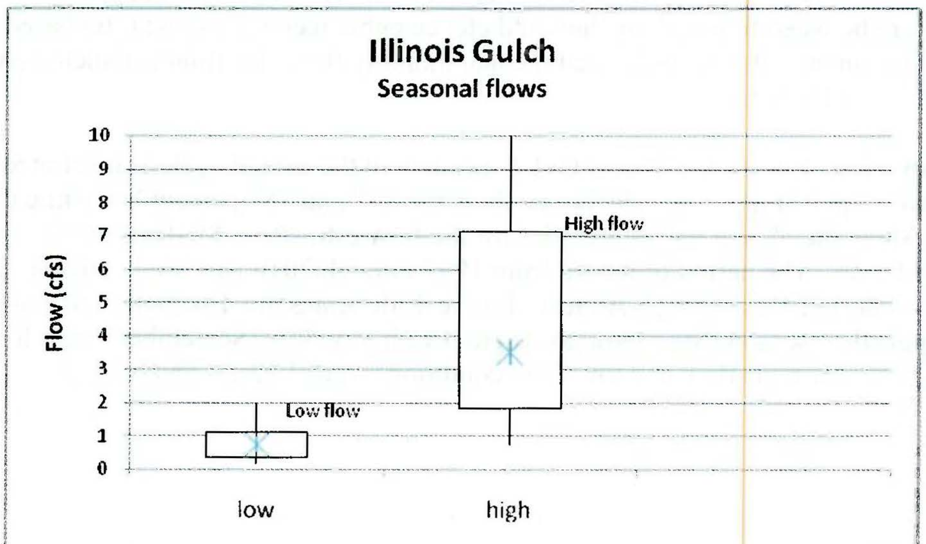

Figure 4. Distribution of flows in Illinois Gulch (low flow vs. high flow)

VII. ANALYSIS OF POLLUTANT SOURCES

Ambient Water Quality Data

Water quality data were collected at one site (Illinois Gulch at the Breckenridge Ice Rink) during routine monitoring by the Colorado Water Quality Control Division (WQCD) from 2001-2007. The WQCD conducted synoptic sampling events; 2 during 2008 and 2 during 2010. Six sites were sampled: sample sites were located upstream from the Puzzle

Mine (Illinois Gulch at Illinois Gulch Road), the Puzzle Mine seepage, Iron Springs Gulch upstream from the confluence with Illinois Gulch, Illinois Gulch upstream of the confluence with Iron Springs Gulch, Illinois Gulch downstream of the confluence with Iron Springs Gulch, and Illinois Gulch at the Breckenridge Ice Rink. The sample sites are shown on the map in Figure 2. The cadmium data collected during October 2008 were suspect, and therefore not included in this assessment. Table 6 presents an assessment of the Illinois Gulch data with all sites pooled.

Illinois Gulch	Hardness (mean) mg/L	Cd-D (ug/L)	n
Illinois Gulch data	121.8	3.8	30
Table Value Standards (chronic)		0.49	

Table 6. Illinois Gulch ambient data summary, (POR = 2001-2007, 2008, 2010).

A summary of the data from each site is shown in Table 7. Means are presented for hardness and 85th percentiles are presented for cadmium for each site. Sites are ordered from upstream to downstream, and show clearly the influence that the Puzzle Mine and Iron Springs Gulch sites have on Illinois Gulch. The two Illinois Gulch sites upstream from the those sites represent background conditions. The dissolved cadmium at these background sites were below water quality standards, while the Puzzle Mine Seepage and Iron Springs Gulch sites, as well as the Illinois Gulch sites downstream from Iron Springs exceeded water quality standards.

Illinois Gulch at Breckenridge Ice Rink is located near the mouth of Illinois Gulch and represents the most downstream site in this data set. The routine monitoring data were collected at this site and it has the longest period of record. Figure 5 illustrates the temporal variability in the cadmium concentrations in Illinois Gulch. The synoptic data from 2008 and 2010 illustrate spatial patterns in the system (Figure 6) and demonstrate that dissolved cadmium concentrations attenuate with distance downstream from the source.

Sampling Sites	Hardness (mean) mg/L	Cd-D (85^{th} percentile) ug/L	n
Illinois Gulch at Illinois Gulch Road (WQCD = 12364F)	77	0	3
Illinois Gulch upstream Iron Springs Gulch (WQCD = 12365D)	75	0	3
Puzzle Mine Seepage (12364B)	227	59.7	3
Iron Springs Gulch upstream Illinois Gulch (WQCD =12364E)	160	6.6	3
Illinois Gulch downstream Iron Springs Gulch (WQCD=12365C)	90	1.6	3
Illinois Gulch at Breckenridge Ice Rink (WQCD=12364)	118	1.4	14
Table Value Standards (chronic)	113	0.47	

Table 7. Illinois Gulch ambient data summary, by site (POR = 2001-2007, 2008, 2010). Sites are ordered upstream to downstream. Table Value Standards based on data for sites downstream from Iron Springs Gulch.

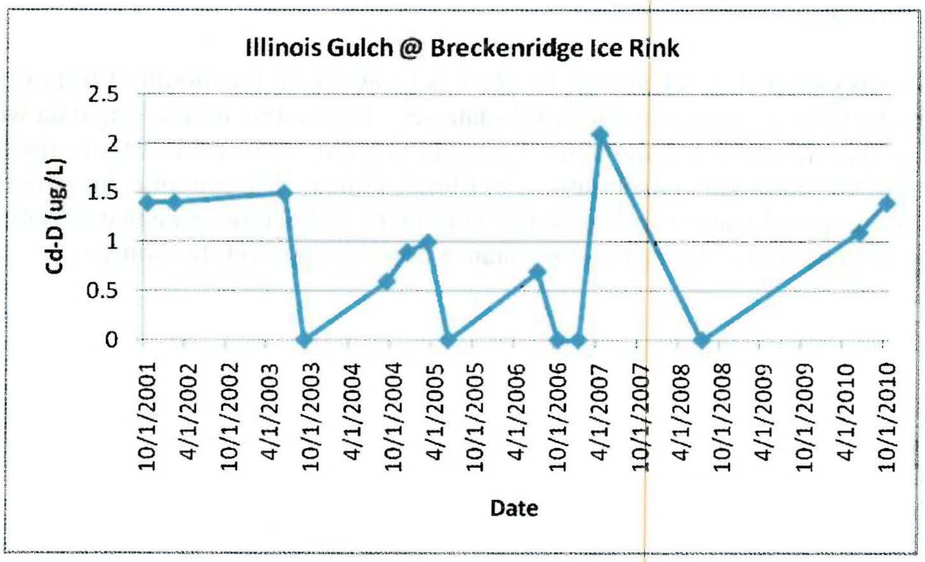

Figure 5. Temporal pattern of dissolved cadmium for Illinois Gulch at Breckenridge Ice Rink (2001-2007, 2008, 2010).

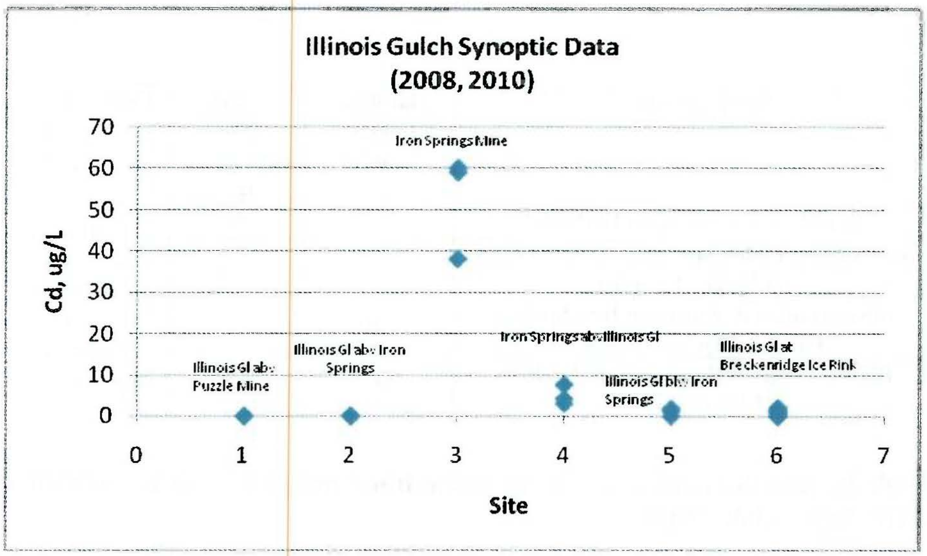

Figure 6. Illinois Gulch Synoptic data (2008, 2010), by site. Sites are ordered, upstream to downstream, as in Table 6.

Chronic Standards

Ambient water quality was determined using the WQCD data described above. For this analysis, two sites upstream from the Puzzle Mine seepage represent background conditions. This background is represented by 3 sampling events conducted during 2008 and 2010. The data from these sampling events showed cadmium concentrations were less than detection level; <0.6 ug/L. The approach typically used in State of Colorado water quality assessments is to assign a value of 0 for data results of less than detection. This is the approach applied here.

Data from the remaining sites, Puzzle Mine, Iron Springs Gulch, and the Illinois Gulch sites downstream from the Iron Springs Gulch, were used to characterize exceedances of the chronic water-quality standards for cadmium. Attainment of chronic Aquatic Life Use-based standards is based upon the 85th percentile of the ranked data. The metals standards are Table Value Standards (TVS) expressed as hardness-based equations. Hardness-based metal standards are evaluated by comparing the 85th percentile value against the assigned hardness-based standard, typically calculated using the mean hardness (Table 8).

Sampling Sites	Hardness (mean) mg/L	Cd-D (85th percentile) ug/L	TVS	n
Puzzle Mine Seepage (12364B)	227	59.7	0.79	3
Iron Springs Gulch upstream Illinois Gulch (WQCD =12364E)	160	6.6	0.60	3
Illinois Gulch downstream Iron Springs Gulch (WQCD=12365C)	90	1.6	0.39	3
Illinois Gulch at Breckenridge Ice Rink (WQCD=12364)	118	1.4	0.48	14

Table 8. Illinois Gulch (sites downstream Iron Springs Gulch) assessment, (POR = 2001-2007, 2008, 2010).

The data also were evaluated using low-flow and high flow seasons. The low-flow and high-flow conditions were determined, and mean hardness values for each were used to calculate the TVS. Table 9 is based on Illinois Gulch sites downstream from Iron Springs Gulch. Table 10 is based on the Puzzle Mine Seepage and Table 11 is based on the Iron Springs Gulch site.

Illinois Gulch			
	Hardness	Cd-D, TVS (ch)	Cd-D (n=16
Low	130	0.52	1.6
High	87	0.38	1.2

Table 9. Illinois Gulch dissolved cadmium exceedances based on hydrologic condition. Ambient concentrations are calculated as 85th %.

Puzzle Mine Seepage			
	Hardness	Cd-D, TVS (ch)	Cd-D
Low	200	0.72	38 (n=1)
High	240	0.82	60 (n=2)

Table 10. Puzzle Mine Seepage dissolved cadmium exceedances based on hydrologic condition. Ambient concentrations are calculated as means.

Iron Springs Gulch			
	Hardness	Cd-D, TVS (ch)	Cd-D
Low	160	0.60	1.8 (n=1)
High	160	0.60	1.2 (n=2)

Table 11. Iron Springs Gulch dissolved cadmium exceedances based on hydrologic condition. Ambient concentrations are calculated as means.

Load Duration Curves

Load duration curves are graphical analytical tools that illustrate the relationships between stream flow and water quality. Flow is an important factor affecting the loading and concentration of metals. Load duration curves are used to characterize water quality data at different flow regimes. A load duration curve consists of a curve that represents the water quality standard of interest and is developed by multiplying stream flow with the numeric water quality target and a conversion factor for the pollutant of concern. This curve, the load duration curve, plotted as a continuous line, represents the loading capacity or allowable load for the water body. Ambient water quality data, taken with a flow measurement associated with the time of sampling, for example, daily mean flow, is used to compute an instantaneous load. By plotting the instantaneous loads with the load duration curve, characteristics of water quality impairment can be described. Instantaneous loads that plot above the curve indicate exceedance of the water quality criterion, while loads that plot below the load duration curve illustrate compliance. The pattern of impairment is examined to see if impairments occur across all flow conditions or under certain flow regimes. For example, impairments observed in the low flow zone typically indicate the influence of point sources, while impairments toward the left side of the curve (i.e., high flow zone) typically reflect nonpoint source contributions.

A cadmium load duration curve for Illinois Gulch was constructed to provide further illustration comparing loads to the standard across all hydrologic conditions (Figure 7). Cadmium exceedances are observed across most flow conditions, which suggest pollutant contributions from groundwater sources, point sources, and additional nonpoint sources from mining features. No data fall under the High Flow category due to the small data set for this study. Very few samples were actually collected under each of the different hydrologic conditions. However, the exceedances occurring under the range of flow conditions observed suggest a continually discharging point source.

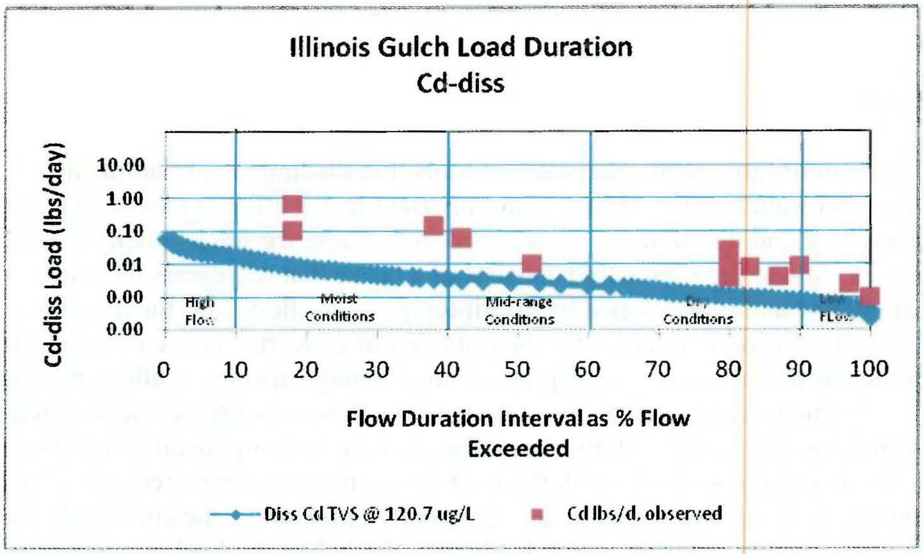

Figure 7. Load duration curve for dissolved cadmium.

Acute Standards

Acute standards are evaluated by comparison of single sample values to standard. The standard is calculated for each sampling event based upon the discrete, sample specific hardness. Data indicate non-attainment of an acute standard if the standard is exceeded more frequently than once in three years.

Attainment of the acute standards for cadmium was assessed for the data from Illinois Gulch sites upstream and downstream from Iron Springs sources, as well as the Iron Springs samples. For this assessment, only samples with paired hardness and cadmium were used. Acute standards for cadmium were attained for the Illinois Gulch sites upstream from Iron Springs. The Puzzle Mine Seepage and Iron Springs Gulch both exceed acute standards for all samples. Illinois Gulch downstream Iron Springs Gulch exceeds the acute cadmium standard during low flow. However, all other samples for sites downstream of Iron Springs Gulch attain the acute cadmium standard (Table 10).

station #	station name	date	Hardness, mg/L	Cd-TVS (Ac-tr)	Cd-D, ug/L amb	Exceedance
12364F	ILLINOIS GULCH @ ILLINOIS GULCH ROAD	7/24/2008	74	1.31	0	no
12364F	ILLINOIS GULCH @ ILLINOIS GULCH ROAD	6/10/2010	65	1.17	0	no
12364F	ILLINOIS GULCH @ ILLINOIS GULCH ROAD	10/14/2010	91	1.57	0	no
12364B	PUZZLE MINE SEEPAGE	7/24/2008	230	3.51	59	yes
12364B	PUZZLE MINE SEEPAGE	6/10/2010	250	3.78	60	yes
12364B	PUZZLE MINE SEEPAGE	10/14/2010	200	3.11	38	yes
12364D	ILLINOIS GULCH UPSTREAM IRON SPRINGS GULCH	7/24/2008	82	1.43	0	no
12364D	ILLINOIS GULCH UPSTREAM IRON SPRINGS GULCH	6/10/2010	65	1.17	0	no
12364D	ILLINOIS GULCH UPSTREAM IRON SPRINGS GULCH	10/14/2010	77	1.36	0	no
12364E	IRON SPRINGS GULCH UPSTREAM ILLINOIS GULCH	7/24/2008	170	2.70	3	yes
12364E	IRON SPRINGS GULCH UPSTREAM ILLINOIS GULCH	6/10/2010	150	2.42	7.6	yes
12364E	IRON SPRINGS GULCH UPSTREAM ILLINOIS GULCH	10/14/2010	160	2.56	4.2	yes
12364C	ILLINOIS GULCH BELOW IRON SPRINGS GULCH	7/24/2008	94	1.61	0	no
12364C	ILLINOIS GULCH BELOW IRON SPRINGS GULCH	6/10/2010	76	1.34	1.2	no
12364C	ILLINOIS GULCH BELOW IRON SPRINGS GULCH	10/14/2010	100	1.70	1.8	yes
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	10/30/2001	120	2.00	1.4	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	2/6/2002	130	2.14	1.4	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	6/30/2003	89	1.54	1.5	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	9/9/2003	130	2.14	0	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	9/29/2004	120	2.00	0.6	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	12/21/2004	180	2.84	0.9	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	3/17/2005	170	2.70	1	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	6/6/2005	83	1.45	0	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	7/27/2006	100	1.70	0.7	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	10/12/2006	120	2.00	0	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	1/9/2007	120	2.00	0	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	4/11/2007	140	2.28	2.1	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	7/24/2008	95	1.63	0	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	6/10/2010	74	1.31	1.1	no
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	10/14/2010	100	1.70	1.4	no

Table 10. Illinois Gulch assessment of exceedances of acute cadmium standards.

VIII. TMDL Allocation

A TMDL is comprised of the Load Allocation (LA), which is that portion of the pollutant load attributed to natural background and/or the nonpoint sources, the Waste Load Allocation (WLA), which is that portion of the pollutant load associated with point source discharges, and a Margin of Safety (MOS). The TMDL may be expressed as the sum of the

LA, WLA and MOS.

$$TMDL = WLA + LA + MOS$$

TMDL = Sum of Waste Load Allocations + Sum of Load Allocations + Margin of Safety

Waste Load Allocations "(WLA)"

There are no identified permitted point sources to this segment. The only source found was the Puzzle Mine Seepage to the Iron Springs Gulch; however there is no CPDES permit for the mine. Limited data for flows and point source water quality were available. Discharge from the mine will be treated as a non-permitted discharge in this TMDL and will be given a waste load allocation.

Load Allocations "(LA)"

Any remaining sources are considered to be non-point sources and are accountable to load allocations.

Margin of Safety "(MOS)"

According to the Federal Clean Water Act, TMDLs require a margin of safety (MOS) component that accounts for the uncertainty about the relationship between the pollutant loads and the receiving waterbody. The margin of safety may be explicit (a separate value in the TMDL) or implicit (included in factors determining the TMDL). In the case of the Illinois Gulch TMDL, a 10% margin of safety was used. As a result, proposed reductions also address exceedances of the acute standards assigned to the listed segment.

The TMDL is calculated using median flows for high-flow and low-flow seasons (estimated from USGS gage #09046940 as described in section VI above), multiplied by the existing stream standard and a conversion factor (0.0054) to approximate a load in pounds/day. This load is reduced by 10% to reflect the margin of safety (MOS). The resulting load is allocated between background nonpoint source for the Load Allocation and the discrete and diffuse sources at the Puzzle Mine site for the Waste Load Allocation.

Observed loads are calculated using eighty-fifth percentile concentrations which are calculated on a flow-season basis and multiplied by corresponding seasonal median flows and a conversion factor (0.0054) to estimate a daily load in pounds/day. Reductions are calculated as the difference between the observed load and the TMDL Load with the 10% MOS.

The TMDL allocations (LA and WLA) are determined by calculating the contribution from background and attributing the remainder to mining influences. Background is the average of the concentrations from the upstream sites. The water quality at these sites was below detection levels for cadmium. The assigned background concentration for cadmium was zero for both flow conditions. Therefore, the LA for cadmium will be 0. The observed loads of cadmium at the downstream site are attributed to mining influence, and the entire cadmium TMDL is allocated to the WLA. TMDLs were calculated for high flow and low flow conditions for the Illinois Gulch downstream Iron Springs Gulch site. Implementation of the TMDL will result in attainment of dissolved cadmium standards at all downstream sites.

TMDL Site	Flow Condition	Cd-D Observed Load	TMDL Load	MOS	TMDL Load (w/10% MOS)	Reduction	Reduction	TMDL LA	TMDL WLA
		(lbs/D)	(lbs/D)	(lbs/D)	(lbs/D)	(lbs/D)	%	(lbs/D)	(lbs/D)
Illinois Gl blw Iron Springs Gl	Low	0.01	0.002	0.0002	0.0018	0.0044	71%	0.00	0.0018
Illinois Gl blw Iron Springs Gl	High	0.02	0.0073	0.0007	0.0066	0.0169	72%	0.00	0.0066

Table 11. Cd TMDL and Load Reduction by flow condition (includes 10% MOS) Segment: COUCBL12. Illinois Gulch

Acute Standards

Attainment of acute standards was evaluated by applying the reduction percentages identified in the table above to individual samples. The reductions resulted in attainment of the acute standards.

IX. RESTORATION PLANNING AND IMPLEMENTATION PROCESS

The monthly percentages of loading reduction necessary to meet TVS standards for cadmium on Illinois Gulch are listed in Table 11. The major source contributing to the elevated level of metals in Illinois Gulch is the Puzzle Mine and non-permitted discharge from the Puzzle Mine property. A substantial reduction of metals from this non-permitted point source is necessary to attain current TVS standards in Illinois Gulch. There is no known cadmium remediation planned for Illinois Gulch.

Monitoring

Additional monitoring of Illinois Gulch beyond routine monitoring performed by the WQCD is not planned at this time. If remediation for cadmium is implemented, monitoring of Illinois Gulch should be required in order to ensure that the TMDL is adequately protective of the segment. Additional water quality and flow monitoring of the drainage from the Puzzle Mine as well as from Illinois Gulch upstream and downstream of the mine would be included for comprehensive monitoring for any remediation efforts.

Conclusion

The goal of this TMDL is the attainment of the TVS for cadmium within the Illinois Gulch portion of Segment 12 of the Blue River. Substantial load reductions of cadmium are necessary to attain the TMDL. The recommended loading reductions should result in attainment of both chronic and acute water quality standards.

X. PUBLIC INVOLVEMENT

This segment was included on Colorado's 303(d) list of impaired segments in 2010. The development of the 303(d) list is a public process involving solicitation from the public of candidate waterbodies, formation of a technical review committee comprised of representatives of both the public and private sector, and a public hearing before the Colorado Water Quality Control Commission. Public notice is provided concerning both the solicitation of impaired waterbodies and the public hearing.

The TMDL itself is the subject of an independent public process. This TMDL report was made available for public review and comment during a 30 day public notice period in April 2011. The EPA provided minimal comments on the draft TMDL. The EPA comments included requests for raw data used in the TMDL analysis, and identification of public notice comments. The WQCD received no comments during the public notice period.

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Phil Hegeman

FEB 01 2010

Ref: 8EPR-EP

Mr. Steve Gunderson
Director
Water Quality Control Division
Colorado Department of Public Health and Environment
4300 Cherry Creek Drive South
Denver, Colorado 80246-1530

Re: TMDL Approvals
Illinois Gulch COUCBL12, Zinc

Dear Mr. Gunderson:

We have completed our review of the total maximum daily loads (TMDLs) as submitted by your office on December 9, 2009 for the waterbody listed in the enclosure to this letter. In accordance with the Clean Water Act (33 U.S.C. 1251 et. seq.), we approve all aspects of TMDLs as developed for certain pollutants in water quality limited waterbodies as described in Section 303(d)(1). Based on our review, we feel the separate TMDL elements for the pollutant listed in the enclosed table are adequately addressed, taking into consideration seasonal variation and a margin of safety.

Thank you for submitting this TMDL for our review and approval. If you have any questions, the most knowledgeable person on my staff is Sandra Spence and she may be reached at (303) 312-6947.

Sincerely,

Eddie A. Sierra

Eddie A. Sierra
Acting Assistant Regional Administrator
Office of Ecosystems Protection
and Remediation

Enclosures

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TOTAL MAXIMUM DAILY LOAD ASSESSMENT
ILLINOIS GULCH
COUCBL12
Zinc

SUMMIT COUNTY, COLORADO
December 2009

TMDL Summary	
Waterbody Description / WBID	Mainstem of Illinois Gulch and Fredonia Gulch from their source to their confluence with the Blue River COUCBL12
Pollutants Addressed	Dissolved zinc
Relevant Portion of Segment (as applicable)	Illinois Gulch
Use Classifications / Designation	Aquatic Life Cold 2, Recreation P, Water Supply, Agriculture;
Water Quality Target	<table><tr><td>Segment 12</td><td>Chronic</td><td>Acute</td></tr><tr><td>Zn-D</td><td>$TVS=0.986e^{0.8525[\ln(hardness)]+0.9109)}$</td><td>$TVS=0.978e^{0.8525[\ln(hardness)]+1.0617)}$</td></tr></table>
TMDL Goal	Attainment of Aquatic Life use classification standards for Zn.

EXECUTIVE SUMMARY

Blue River Segment 12, Illinois Gulch, has been on the State's 303(d) list of water-quality impaired waterbodies for nonattainment of water quality standards for dissolved zinc since 2004, when it was given a high priority (Table 1). Excess dissolved zinc impairs the Aquatic Life Cold 1 classification for Segment 12. The high concentration of dissolved zinc is primarily the result of mining activity in the watershed since the1880's. Illinois Gulch is located near Breckenridge in Summit County, Colorado. Water quality in Illinois Gulch above the Iron Springs Gulch (and influence of the Puzzle Mine) is in attainment of assigned standards while water quality below the mine has elevated zinc levels. Acid mine drainage enters Illinois Gulch via Iron Springs Gulch.

Segment #	Segment Description	Portion	303(d) Listed Contaminants
Segment 12	Mainstem of Illinois Gulch and Fredonia Gulch from their source to their confluence with the Blue River	Illinois Gulch	Zn

Table 1. Segment within the Blue River watershed that appears on the 2004, 2006 and 2008 303(d) list of impaired water bodies.

II. INTRODUCTION

Section 303(d) of the federal Clean Water Act (CWA) requires states to periodically submit to the U.S. Environmental Protection Agency (EPA) a list of water bodies that are water-quality impaired. Water-quality limited segments are those water bodies that, for one or more assigned use classifications or standards, the classification or standard is not fully achieved. This list of water bodies is referred to as the "303(d) List". In Colorado, the agency responsible for developing the 303(d) list is the Water Quality Control Division (WQCD). The List is adopted by the Water Quality Control Commission (WQCC) as Regulation No. 93. The WQCC adopted the current 303(d) list March of 2008.

For waterbodies and streams on the 303(d) list a Total Maximum Daily Load (TMDL) is used to determine the maximum amount of a pollutant that a water body may receive and still maintain water quality standards. The TMDL is the sum of the Waste Load Allocation (WLA), which is the load from point source discharge, Load Allocation (LA) which is the load attributed to natural background and/or non-point sources, and a Margin of Safety (MOS) (Equation 1).

(Equation 1) $$TMDL=WLA+LA+MOS$$

Alternatively, a segment or pollutant may be removed from the list if the applicable standard is attained, if implementation of clean-up activities via alternate means will result in attainment of standards, if the original listing decision is shown to be in error or if the standards have been changed as the result of a Use Attainability Analysis (UAA), or other EPA approved recalculation method.

Illinois Gulch is a portion of Segment 12 (the mainstem of Illinois Gulch and Fredonia Gulch from their source to their confluence with the Blue River) and is identified on the 2004, 2006 and 2008 303(d) lists for exceeding the water quality standards for dissolved zinc (Table 1) (WQCC, 2008a). The impairment status for designated uses in Illinois Gulch is presented in Table 2.

Date (Cycle Year) of Current Approved 303(d) list: 2008		
WBID	**Segment Description**	**Designated Uses & Impairment Status**
COUCBL12	Mainstem of Illinois Gulch and Fredonia Gulch from their source to their confluence with the Blue River	Aquatic Life Cold 2: Impaired Recreation P: Not Impaired Water Supply: Not Impaired Agriculture: Not Impaired

Table 2. Designated uses and impairment status for Segment 12, Illinois Gulch.

During April 2006, EPA responded to a reported problem in the vicinity of Illinois Gulch. The Puzzle Mine discharged a slug of orange water which flowed through a gulch (named here as Iron Springs Gulch) through Illinois Gulch into Breckenridge. No fish kills were reported to EPA (Hayes Griswold, pers. comm., 2009). Some monitoring was conducted on Illinois Gulch, in the vicinity of the mine, and in the Blue River. However, the data were not used in this assessment. No hardness data were reported for this sampling event and metals were reported as total metals, while the standards are based on the dissolved fraction. It was suspected that an ice dam had formed at the adit, which broke loose during the spring, and released the backed-up water. This type of event has not been observed since then, although there continues to be seepage from the Puzzle Mine.

Geographical Extent

This listed portion of the Blue River Watershed is part of the Colorado River Blue River Basin, Hydrologic Unit Code (HUC) 14010002 and is located in Summit County. Deposits of gold and silver were mined in the watershed beginning in 1870s (Summit Historical Society of Summit County, *www.**summithistorical**.org*).

Illinois Gulch is part of the headwaters reach of the Blue River watershed. The drainage area of Illinois River watershed is 8.08 km^2. The elevation at the mouth of Illinois Gulch is 2932 meters. The mean annual precipitation is approximately 501.14 millimeters. As a headwaters tributary, Illinois Gulch is snowmelt dominated. Heavy metal pollution probably results from a combination of both natural and anthropogenic sources, heavily dominated by acid mine drainage from the Puzzle Mine, a non-active, historical mine site.

Illinois Gulch flows north parallel to Illinois Gulch Road, crosses Boreas Pass Road, flowing northwest where it confluences with Iron Springs Gulch. Iron Springs Gulch seems to originate as seepage near the Puzzle Mine Site, which is located in a large U-shaped curve made by Boreas Pass Road. The Iron Springs Gulch flows in a northerly direction to its confluence with Illinois Gulch. Illinois Gulch continues parallel to Boreas Pass Road, past the Breckenridge Ice Arena and eventually flows into the Blue River.

A map of the study area is shown in Figure 1. Associated sampling sites are marked on the Google Earth photo in Figure 2.

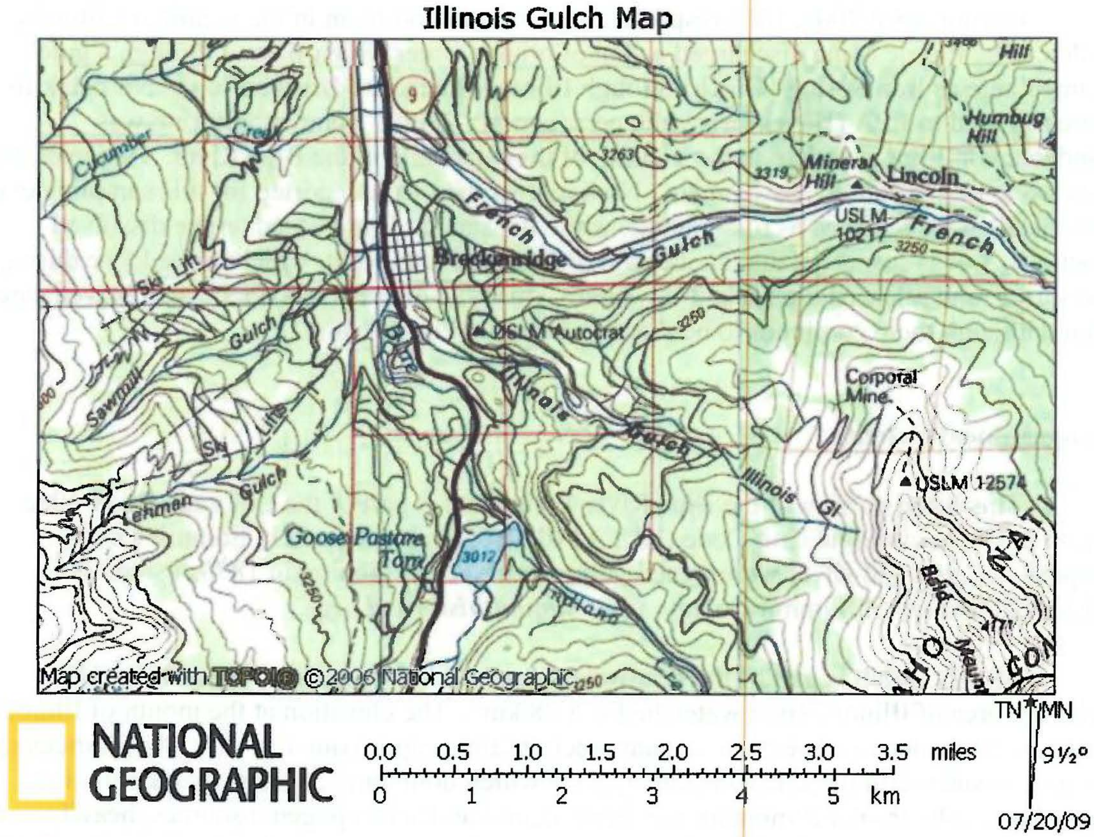


Figure 1. Illinois Gulch

Figure 2. Google Earth image of Illinois Gulch monitoring locations.

III. WATER QUALITY STANDARDS

Standards Framework

Waterbodies in Colorado are divided into discrete units or "segments". The Colorado *Basic Standards and Methodologies for Surface Water*, Regulation 31(WQCC 2006b), discusses segmentation of waterbodies in terms of several broad considerations:

> *31.6(4)(b)...Segments may constitute a specified stretch of a river mainstem, a specific tributary, a specific lake or reservoir, or a generally defined grouping of waters within the basin (e.g., a specific mainstem segment and all tributaries flowing into that mainstem segment.*

> *(c) Segments shall generally be delineated according to the points at which the use, physical characteristics or water quality characteristics of a watercourse are determined to change significantly enough to require a change in use classifications and/or water quality standards*

As noted in paragraph 31.6(4)(c), the use or uses of surface waters are an important consideration with respect to segmentation. In Colorado there are four categories of beneficial use which are recognized. These include Aquatic Life Use, Recreational Use, Agricultural Use and Water Supply Use. A segment may be designated for any or all of these "Use Classifications":

> *31.6 Waters shall be classified for the present beneficial uses of the water or the beneficial uses that may be reasonably expected in the future for which the water is suitable in its present condition or the beneficial uses for which it is to become suitable as a goal.*

Each assigned use is associated with a series of pollutant specific numeric standards. These pollutants may vary and are relevant to a given Classified Use. Numeric pollutant criteria are identified in sections 31.11 and 31.16 of the *Basic Standards and Methodologies for Surface Water.*

Uses and Standards Addressed in this TMDL

The Colorado Basic Standards and Methodologies for Surface Water, Regulation 31 identifies standards applicable to all surface waters statewide (WQCC 2006b). The pollutant of concern for this assessment is dissolved zinc. In the case of Illinois Gulch, zinc concentrations exceed Aquatic Life Use-based standards intended to protect against short-term, acutely toxic conditions (acute) and longer-term, sub-lethal (chronic) effects.

Chronic and acute standards are designed to protect against different ecological effects of pollutants (long term exposure to relatively lower pollutant concentrations vs. short term exposure to relatively higher pollutant concentrations). Where chronic standards are assigned, they are used because they represent a more conservative approach than the acute standards. Chronic standards represent the level of pollutants that protect 95 percent of the genera from chronic toxic effects of metals. By reducing metals concentrations to attain the chronic standard, the acute standard will also be attained. Per Regulation 31, chronic toxic effects include but are not limited to demonstrable abnormalities and adverse effects on survival, growth, or reproduction (WQCC 2006b).

The specific numeric standards assigned to the listed stream segments are contained in Regulation 33, the Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12) (WQCC, 2006c) (Table 3). In addition to the dissolved zinc listing, it is likely that Illinois Gulch will be listed for dissolved cadmium (aquatic life use-based acute and chronic standards) on the 2010 303(d) list. All remaining assigned numeric standards associated with Aquatic Life, Recreational, Water Supply and Agricultural Use Classifications are attained.

Water Quality Criteria for Impaired Designated Uses		
WBID	**Impaired Designated Use**	**Applicable Water Quality Criteria and Status**
COUCBL12	Aquatic Life Cold 2	Dissolved Phase Zn (1) / Not Attained
Applicable State or Federal Regulations: (1) Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12), (Regulation No. 33)		

Table 3. Ambient water quality criteria and status for Segment 12, Illinois Gulch.

The relevant standards for the stream segment addressed in this document are Table Value Standards (TVS), which vary based on hardness. Hardness fluctuates seasonally, therefore, standards are shown for low-flow and high-flow seasons (Table 4). The low-flow season is from September through April, while the high-flow season was from May through August. Aquatic Life Use-based metals standards, identified as Table Value Standards or "TVS", are typically hardness based (arsenic, mercury and selenium are exceptions). Aquatic Life Use-based TVS for metals usually are expressed as the dissolved fraction, as opposed to the total metal fraction. Again, there are exceptions, namely aluminum, iron and, again, mercury. Zinc standards assigned for the protection of aquatic life are both expressed as the dissolved metal fraction and are hardness based.

Season	Hardness mg/L	Zn-D, ug/L TVS (ch)	Zn-D ug/L TVS (ac)
Low-flow	111	135.9	156.7
High-flow	69	90.6	104.5

Table 4. Average hardness and table value standards (chronic and acute) for 303(d) listed segment of Illinois Gulch. Data are from the Colorado Water Quality Control Division.

IV. PROBLEM IDENTIFICATION

Much of the heavy metal loading throughout the Blue River basin is the result of natural geologic conditions and historic mining activities. The Blue River watershed began experiencing widespread mining activity throughout the basin beginning in the 1870's. Several historical mine sites are located in the vicinity of Illinois Gulch. The Puzzle Ouray Mine site is located inside of a large curve (north side of road) made by Boreas Pass Road just before Illinois Gulch Road. Commodities from the mine included gold, zinc, lead, silver, and copper. Mining operations resulted in residual levels of elevated zinc concentrations in Illinois Gulch. Seepage from the mine site enters a gulch, named here as Iron Springs Gulch, which is tributary to Illinois Gulch. There are no permitted dischargers to Illinois Gulch.

The high metals concentrations in Illinois Gulch exceed the standards to protect aquatic life.

V. WATER-QUALITY GOAL AND TARGET

The water quality goal for the 303(d) listed segment, Illinois Gulch, is attainment of the Aquatic Life Cold 2 use classification standards for dissolved zinc.

VI. INSTREAM CONDITIONS

Hydrology

The hydrograph of the Blue River (Figure 2) should approximate the pattern of the Illinois Gulch hydrograph, although at a larger magnitude. Such hydrographs are typical of high mountain streams, with low flows occurring in the late fall to early spring followed by a large increase in flow, usually in May or June, due to snowmelt that tails off through the summer (Figure 3, Table 5).

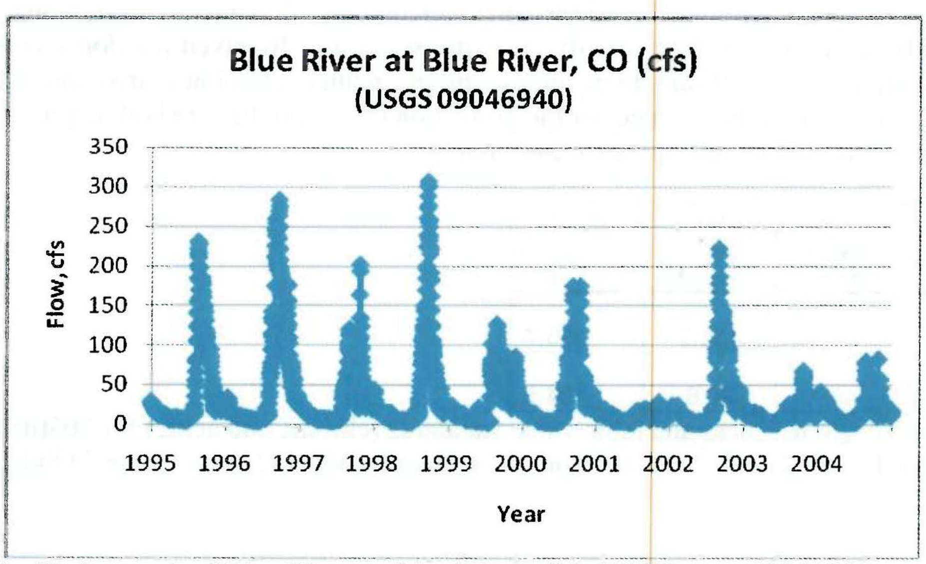


Figure 2. Hydrograph of Blue River at Blue River, CO, USGS gage 09046940.

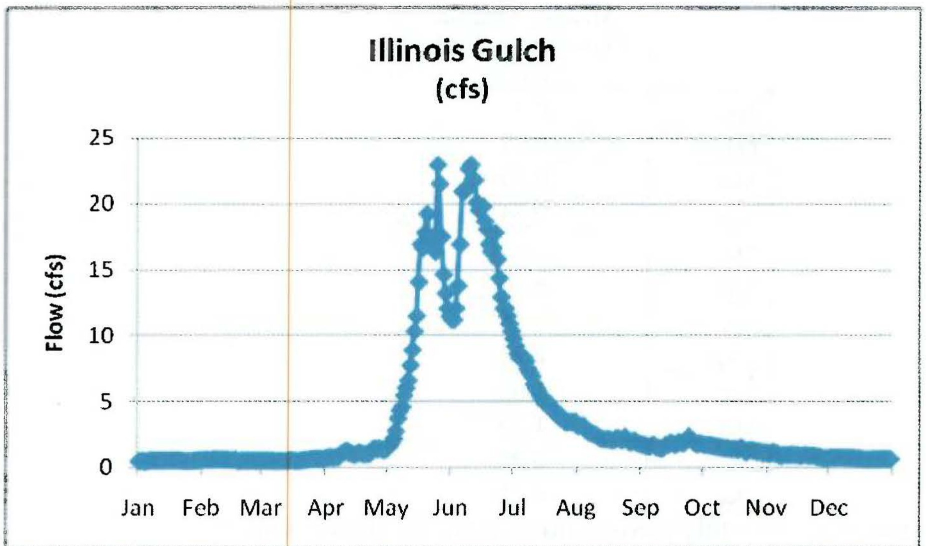


Figure 3. Annual hydrograph for Illinois Gulch

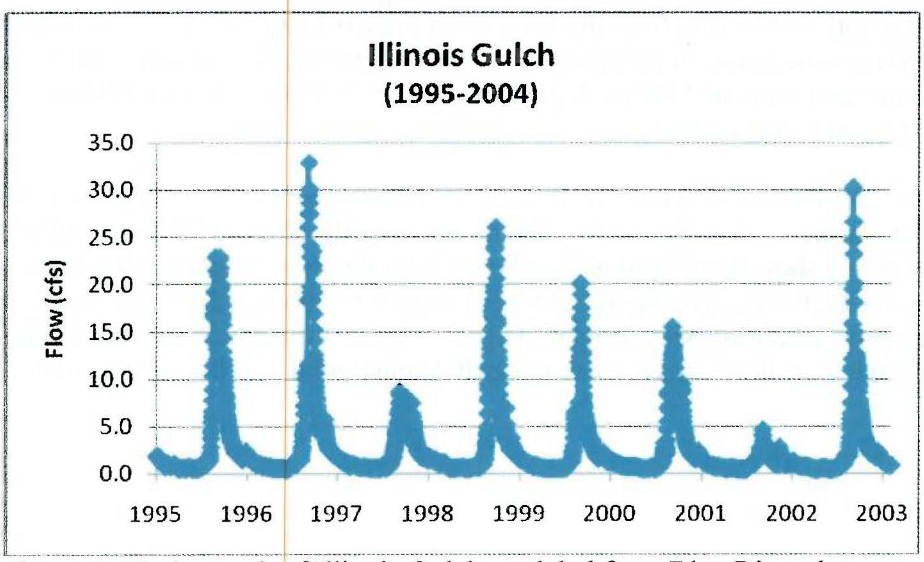


Figure 4. Hydrograph of Illinois Gulch modeled from Blue River data.

	Monthly Median. Flow Illinois Gulch. (cfs)
Jan	0.45
Feb	0.35
Mar	0.29
Apr	0.54
May	3.94
Jun	8.20
Jul	5.48
Aug	2.28
Sep	1.62
Oct	1.25
Nov	0.96
Dec	0.71

Table 5. Estimated monthly median flows (cfs), for Illinois Gulch.

Flows for the Blue River were obtained from USGS gage #09046940 near Blue River, Colorado. Illinois Gulch flows were estimated using a watershed area ratio (0.074) and applying the ratio to the data from the Blue River gage (Figure 4). Median monthly flows in the Blue River were between four and one hundred eleven cubic feet per second (cfs) based on instantaneous and estimated flows. Estimated median monthly flows for Illinois Gulch were between 0.3 and 8 cfs (Table 5).

The distribution of flows for Illinois Gulch throughout the annual cycle is illustrated in a "box and whiskers" plot (Figure 3). The boxes show the 25th and 75th percentiles, while the bars or whiskers show the 5th and 95th percentiles for the flow estimates. Medians are shown as markers in the boxes. The period of record from 1995 through 2009 was used. Higher flows are observed during May through August. Figure 4 illustrates the distribution of flows comparing the high-flow season (May through August) with low flow (September through April).

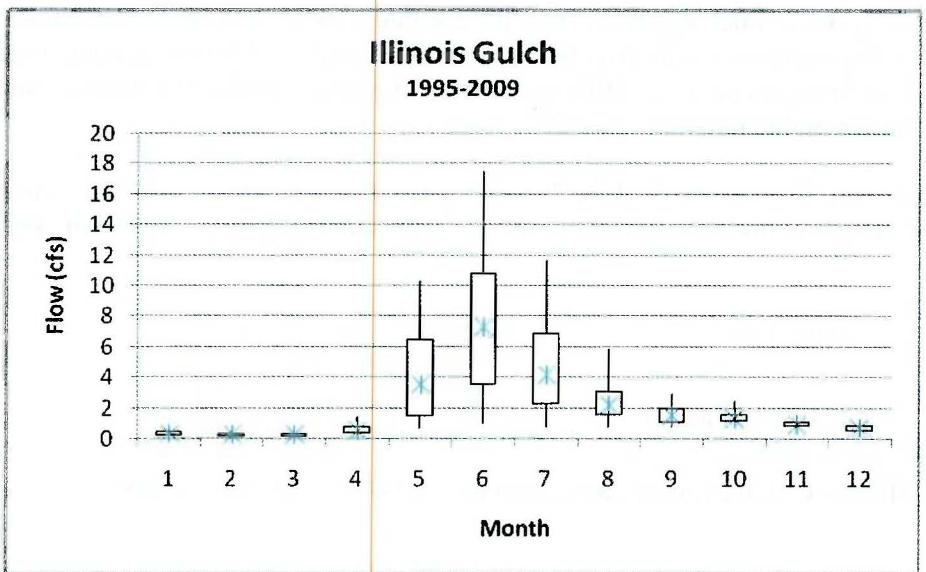


Figure 3. Distribution of flows in Illinois Gulch (by month)

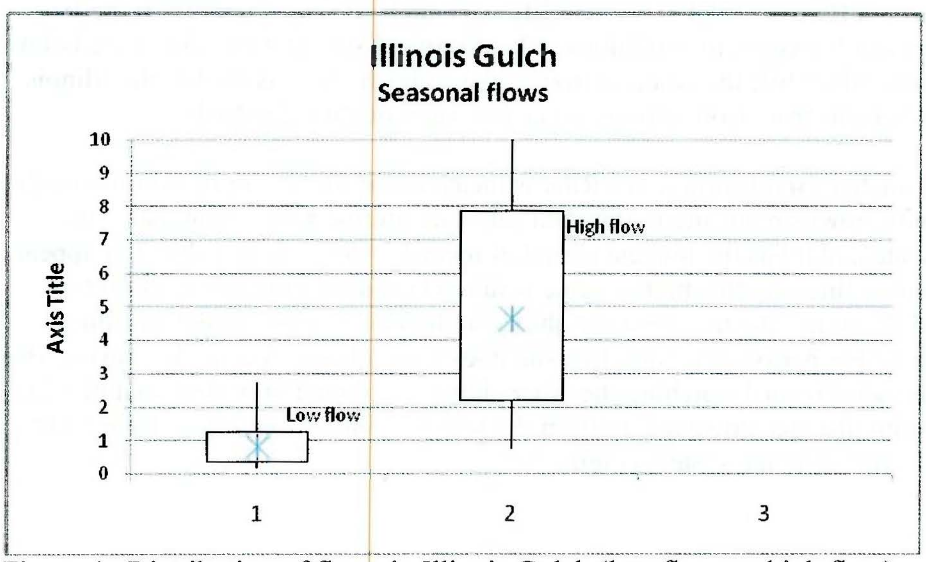


Figure 4. Distribution of flows in Illinois Gulch (low flow vs. high flow)

VII. ANALYSIS OF POLLUTANT SOURCES

Ambient Water Quality Data

Water quality data were collected during routine monitoring by the Colorado Water Quality Control Division (WQCD) from 2001-2007. The WQCD conducted 2 synoptic sampling events during 2008. Six sites were sampled: sample sites were located upstream from the Puzzle Mine (Illinois Gulch at Illinois Gulch Road), the Puzzle Mine seepage (Iron

Springs Adit), Iron Springs Gulch upstream from the confluence with Illinois Gulch, Illinois Gulch upstream of the confluence with Iron Springs Gulch, Illinois Gulch downstream of the confluence with Iron Springs Gulch, and Illinois Gulch at the Breckenridge Ice Arena. The sample sites are shown on the map in Figure 2.

Table 6 presents an assessment of the Illinois Gulch data with all sites pooled. The two Iron Springs sites were not included, as these sites represent the primary source of zinc to Illinois Gulch.

Illinois Gulch	Hardness (mean) mg/L	Zn-D (ug/L)	n
Illinois Gulch data	114.3	483	20
Table Value Standards (chronic)		132.3	

Table 6. Illinois Gulch ambient data summary, (POR = 2001-2007, 2008).

A summary of the data from each site is shown in Table 7. The number of sampling events were limited; therefore, means for each site are presented for zinc, pH, and hardness. Sites are ordered from upstream to downstream, and show clearly the influence that the Iron Springs sites have on Illinois Gulch. The two Illinois Gulch sites upstream from the Iron Spring sites represent background conditions. The dissolved zinc at these sites were below water quality standards, while the adit and Iron Springs Gulch sites, as well as the Illinois Gulch sites downstream from Iron Springs exceeded water quality standards.

Illinois Gulch at Breckenridge Ice Rink is located near the mouth of Illinois Gulch and represents the most downstream site in this data set. The routine monitoring data were collected at this site and it has the longest period of record. Although in Table 7, it appears that zinc increases at this site, this higher value resulted because of the longer period of record. Figure 5 illustrates the temporal variability in the zinc concentrations in Illinois Gulch. For the longer period of record, this site does have a higher value. However, when data from the period of record matching the other sites is examined, it is clear that dissolved zinc attenuates with distance downstream from the source. The synoptic data from 2008 illustrate spatial patterns in the system (Figure 6).

Sampling Sites	Hardness (mean) mg/L	pH (s.u.)	Zn-D (ug/L)	n
Illinois Gulch at Illinois Gulch Road (WQCD = 12364F)	86	7.4	92	2
Illinois Gulch upstream Iron Springs Gulch (WQCD = 12365D)	91	8.3	79.5	2
Puzzle Mine Adit (Seepage) (12364B)	235	3.5	7125	2
Iron Springs Gulch upstream Illinois Gulch (WQCD =12364E)	185	7	735	2
Illinois Gulch downstream Iron Springs Gulch (WQCD=12365C)	107	7.9	210	2
Illinois Gulch at Breckenridge Ice Rink (WQCD=12364)	123	7.9	369	14
Table Value Standards (chronic)		6.5-9.0	155.66	

Table 7. Illinois Gulch ambient data summary, by site (POR = 2001-2007, 2008). Sites are ordered upstream to downstream.

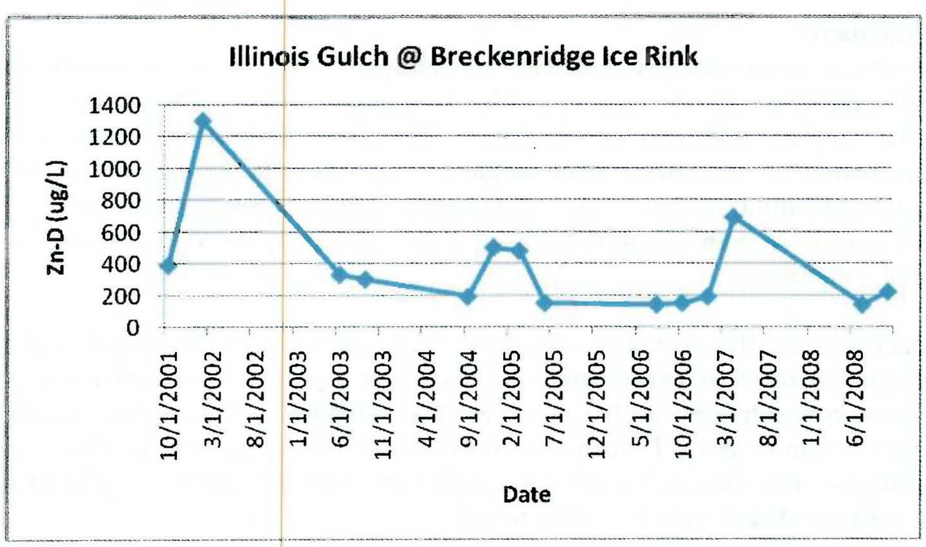


Figure 5. Temporal pattern of dissolved zinc for Illinois Gulch at Breckenridge Ice Rink (2001-2008).

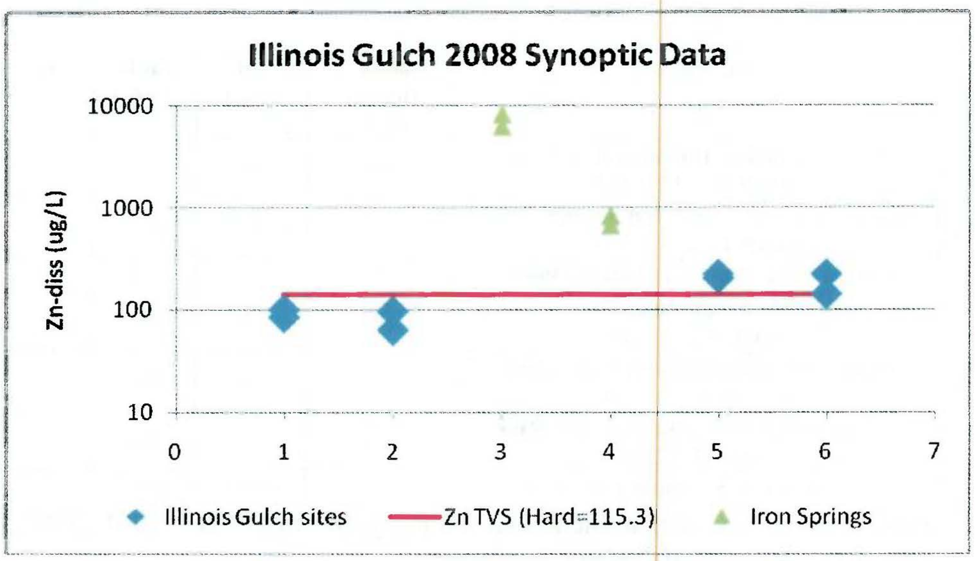


Figure 6. Illinois Gulch 2008 Synoptic data, by site. Sites are ordered, upstream to downstream, as in Table 6.

Chronic Standards

Ambient water quality was determined using the WQCD data described above. For this analysis, the upstream site represented background conditions. Background is represented by only two sampling events conducted during 2008. Two sites for each sampling event were located upstream from the Puzzle Mine seepage. The data from these sampling events showed zinc concentrations were below the chronic standards for dissolved zinc. The mean for the two sites from both sampling events will be assigned as the value for natural background conditions,

Data from the Illinois Gulch sites downstream from the Iron Springs Gulch were used to identify and characterize exceedances of the chronic water-quality standards for zinc. The 85th percentile concentration for dissolved zinc was compared to the chronic standard (Table 8). The metals standards are Table Value Standards (TVS) and are expressed as hardness-based equations. The standards were calculated using the mean hardness value of 120.7 mg/L from the available data for the period of record.

Illinois Gulch	Hardness (mean) mg/L	Zn-D (ug/L)	n
Illinois Gulch downstream Iron Springs	120.7	495	16
Table Value Standards (chronic)		145.9	

Table 8. Illinois Gulch (sites downstream Iron Springs Gulch) assessment, (POR = 2001-2007, 2008).

The data also were evaluated using low-flow and high flow seasons. The low-flow and high-flow conditions were determined, and mean hardness values for each were used to calculate the TVS. Attainment of chronic Aquatic Life Use-based standards is based upon the 85th percentile of the ranked data. Percentile values are calculated by ranking individual data points in order of magnitude. Hardness-based metal standards are evaluated by comparing the 85th percentile value against the assigned hardness-based standard (typically calculated using the mean hardness) (Table 9).

Illinois Gulch			
	Hardness	Zn-D, TVS (ch)	Zn-D (n=16
Low	134	159.5	595
High	92	115.8	252

Table 9. Illinois Gulch dissolved zinc exceedances based on hydrologic condition. Ambient concentrations are calculated as 85^{th} %.

Load Duration Curves

Load duration curves are graphical analytical tools that illustrate the relationships between stream flow and water quality. Flow is an important factor affecting the loading and concentration of metals. Load duration curves are used to characterize water quality data at different flow regimes. A load duration curve consists of a curve that represents the water quality standard of interest and is developed by multiplying stream flow with the numeric water quality target and a conversion factor for the pollutant of concern. This curve, the load duration curve, plotted as a continuous line, represents the loading capacity or allowable load for the water body. Ambient water quality data, taken with a flow measurement associated with the time of sampling, for example, daily mean flow, is used to compute an instantaneous load. By plotting the instantaneous loads with the load duration curve, characteristics of water quality impairment can be described. Instantaneous loads that plot above the curve indicate exceedance of the water quality criterion, while loads that plot below the load duration curve illustrate compliance. The pattern of impairment is examined to see if impairments occur across all flow conditions or under certain flow regimes. For example, impairments observed in the low flow zone typically indicate the influence of point sources, while impairments toward the left side of the curve typically reflect nonpoint source contributions.

A zinc load duration curve for Illinois Gulch was constructed to provide further illustration comparing loads to the standard across all hydrologic conditions (Figure 7). For this figure, data from all sites were used. Zinc exceedances are observed across most flow conditions, which suggests pollutant contributions from groundwater sources, point sources, and additional nonpoint sources from mining features. Although no exceedances were observed under the High Flow category, this may be due to the small data set for this study. Very few samples were actually collected under each of the different hydrologic conditions.

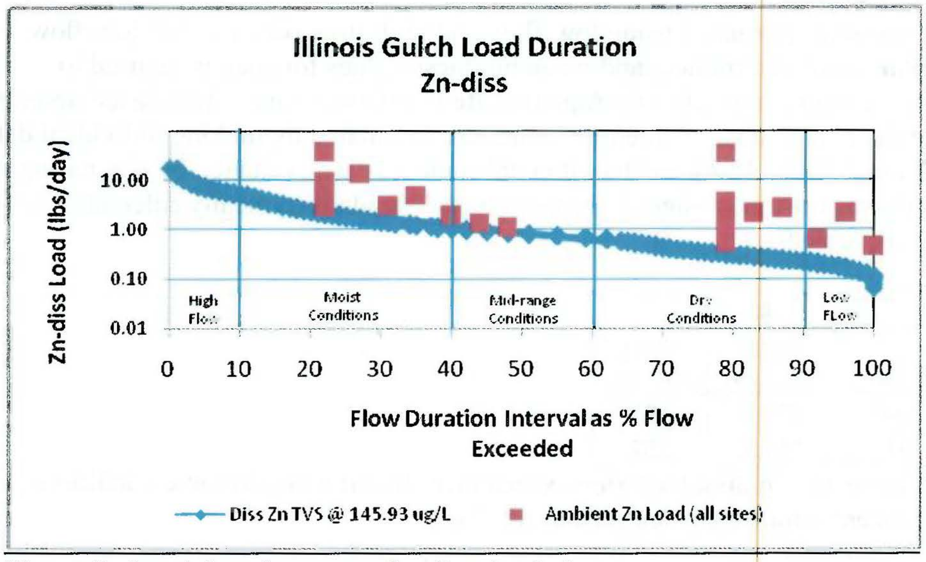


Figure 7. Load duration curve for dissolved zinc.

Acute Standards

Acute standards are evaluated by comparison of single sample values to standard. The standard is calculated for each sampling event based upon the discrete, sample specific hardness. Data indicate non-attainment of an acute standard if the standard is exceeded more frequently than once in three years.

Attainment of the acute standards for zinc was assessed for the data from Illinois Gulch sites upstream and downstream from Iron Springs sources, as well as the Iron Springs samples. For this assessment, only samples with paired hardness and zinc were used. Acute standards for zinc were attained for the Illinois Gulch sites upstream from Iron Springs; however, all other sites show exceedance of the acute zinc standards (Table 10).

station #	Station	date	hardness	Zn TVS (Ac)	Zn amb	Exceedance=1
12346F	ILLINOIS GULCH @ ILLINOIS GULCH ROAD	7/24/2008	74	110.90	84	0
12346F	ILLINOIS GULCH @ ILLINOIS GULCH ROAD	10/29/2008	98	140.91	100	0
12364D	ILLINOIS GULCH UPSTREAM IRON SPRINGS GULCH	7/24/2008	82	121.05	63	0
12364D	ILLINOIS GULCH UPSTREAM IRON SPRINGS GULCH	10/29/2008	100	143.36	96	0
12364B	PUZZLE MINE ADIT	7/24/2008	230	291.61	8100	1
12364B	PUZZLE MINE ADIT	10/29/2008	240	302.38	6150	1
12364E	IRON SPRINGS GULCH UPSTREAM ILLINOIS GULCH CONFLUENCE	7/24/2008	170	225.37	810	1
12364E	IRON SPRINGS GULCH UPSTREAM ILLINOIS GULCH CONFLUENCE	10/29/2008	200	258.86	660	1
12364C	ILLINOIS GULCH BELOW IRON SPRINGS GULCH	7/24/2008	94	135.99	200	1
12364C	ILLINOIS GULCH BELOW IRON SPRINGS GULCH	10/29/2008	120	167.47	220	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	10/30/2001	120	167.47	390	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	2/6/2002	130	179.29	1300	1

12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	6/30/2003	89	129.80	330	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	9/9/2003	130	179.29	300	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	9/29/2004	120	167.47	190	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	12/21/2004	180	236.62	500	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	3/17/2005	170	225.37	480	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	6/6/2005	83	122.30	150	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	7/27/2006	100	143.36	140	0
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	10/12/2006	120	167.47	150	0
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	1/9/2007	120	167.47	190	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	4/11/2007	140	190.99	690	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	7/24/2008	95	137.23	140	1
12364	ILLINOIS GULCH @ BRECKENRIDGE ICE RINK	10/29/2008	120	167.47	220	1

Table 10. Illinois Gulch assessment of exceedances of acute zinc standards.

VIII. TMDL Allocation

A TMDL is comprised of the Load Allocation (LA), which is that portion of the pollutant load attributed to natural background and/or the nonpoint sources, the Waste Load Allocation (WLA), which is that portion of the pollutant load associated with point source discharges, and a Margin of Safety (MOS). The TMDL may be expressed as the sum of the LA, WLA and MOS.

$$TMDL = WLA + LA + MOS$$

TMDL = Sum of Waste Load Allocations + Sum of Load Allocations + Margin of Safety

Waste Load Allocations "(WLA)"

There are no identified permitted point sources to this segment. The only source found was the Puzzle Mine seepage to the Iron Springs Gulch; however there is no CPDES permit for the mine. Limited data for flows and water quality were available. Discharge from the mine will be treated as a non-permitted discharge in this TMDL and will be given a waste load allocation.

Load Allocations "(LA)"

Any remaining sources are considered to be non-point sources and are accountable to load allocations.

Margin of Safety "(MOS)"

According to the Federal Clean Water Act, TMDLs require a margin of safety (MOS) component that accounts for the uncertainty about the relationship between the pollutant loads and the receiving waterbody. The margin of safety may be explicit (a separate value in the TMDL) or implicit (included in factors determining the TMDL). In the case of the Illinois Gulch TMDL, a 10% margin of safety was used. As a result, proposed reductions also address exceedances of the acute standards assigned to the listed segment.

The TMDL is calculated using median flows for high-flow and low-flow seasons (estimated from USGS gage #09046940 as described in section VI above), multiplied by the existing stream standard and a conversion factor (0.0054) to approximate a load in pounds/day. Eighty-fifth percentile concentrations are calculated on a flow-season basis and multiplied by corresponding seasonal median flows and a conversion factor (0.0054) to estimate a daily load in pounds/day. This load is reduced by 10% to reflect the margin of safety (MOS). The resulting load is allocated between background nonpoint source for the Load Allocation and the discrete and diffuse sources at the Puzzle Mine site for the Waste Load Allocation.

The TMDL allocations (LA and WLA) are determined by calculating the contribution from background and attributing the remainder to mining influences. Background is the average of the concentrations from the upstream sites. The assigned background concentration for zinc is 98 ug/L during low flow, and 73.5 ug/L during high flow. The seasonal background concentration for zinc is multiplied by the seasonal median flow to determine the LA. The WLA is calculated as the difference between the allowable TMDL and the LA. Table 11 presents the TMDL, MOS, LA, and WLA for zinc for low flow and high flow, respectively.

	Zn-D Observed Load	TMDL Load	MOS	TMDL Load (w/10% MOS)	Reduction	Reduction	TMDL LA	TMDL WLA
Flow	(lbs/D)	(lbs/D)	(lbs/D)	(lbs/D)	(lbs/D)	%	(lbs/D)	(lbs/D)
Low	2.60	0.70	0.07	0.63	1.97	76%	0.43	0.20
High	6.31	2.90	0.29	2.61	3.7	59%	1.84	0.77

Table 11. Zn TMDL and Load Reduction by flow condition (includes 10% MOS)
Segment: COUCBL12. Illinois Gulch (n=16)

Acute Standards

Attainment of acute standards was evaluated by applying the reduction percentages identified in the table above to individual samples. The reductions resulted in attainment of the acute standards in 19 of 24 samples (5 exceedances). Although acute exceedances were estimated for zinc, three of the exceedances were for samples from the mine adit and Iron Springs Gulch. The remaining two exceedances were for sites downstream from the mine. However, these exceedances were for samples collected prior to 2004. In the Division's assessments for attainment of standards, assessments are based on the most recent 5 years of data. In the Illinois Gulch data from 2004-2008, no acute exceedances for zinc would be observed with the TMDL reductions. Based on this rationale, acute standards for zinc would be attained through the above TMDLs.

IX. RESTORATION PLANNING AND IMPLEMENTATION PROCESS

The monthly percentages of loading reduction necessary to meet TVS standards for copper and zinc on Illinois Gulch are listed in Table 11. The major source contributing to the elevated level of metals in Illinois Gulch is the Puzzle Mine and non-permitted discharge from the Puzzle Mine property. A substantial reduction of metals from this non-permitted point source is necessary to attain current TVS standards in Illinois Gulch. There is no known zinc remediation planned for Illinois Gulch.

Monitoring

Additional monitoring of Illinois Gulch beyond routine monitoring performed by the WQCD is not planned at this time. If remediation for zinc is implemented, monitoring of Illinois Gulch should be required in order to ensure that the TMDL is adequately protective of the segment. Additional water quality and flow monitoring of the drainage from the Puzzle Mine as well as from Illinois Gulch upstream and downstream of the mine would be included for comprehensive monitoring for any remediation efforts.

Conclusion

The goal of this TMDL is the attainment of the TVS for zinc within the Illinois Gulch portion of Segment 12 of the Blue River. Substantial loading reductions of zinc are necessary to attain the TMDL for each metal. The recommended loading reductions should result in attainment of both chronic and acute water quality standards.

X. PUBLIC INVOLVEMENT

This segment was included on Colorado's 303(d) list of impaired segments in 2006. The development of the 303(d) list is a public process involving solicitation from the public of candidate waterbodies, formation of a technical review committee comprised of representatives of both the public and private sector, and a public hearing before the Colorado Water Quality Control Commission. Public notice is provided concerning both the solicitation of impaired waterbodies and the public hearing.

The TMDL itself is the subject of an independent public process. This TMDL report was made available for public review and comment during a 30 day public notice period in November, 2009. The EPA provided minimal comments on the draft TMDL. The EPA comments included requests for clarification in the TMDL calculations and additional information in the TMDL tables, request for raw data used in the TMDL analysis, and identification of public notice comments. The WQCD received no additional comments during the public notice period.

References

Summit Historical Society of Summit County, http://www.summithistorical.org/Washington.html.

Waugh, Rebecca, Breckenridge Town Historian, Personal Communication (July 2009).

Thomann, R.V., and J.A. Mueller. 1987. *Principles of Surface Water Quality Modeling and Control.* Harper & Row, New York, NY.

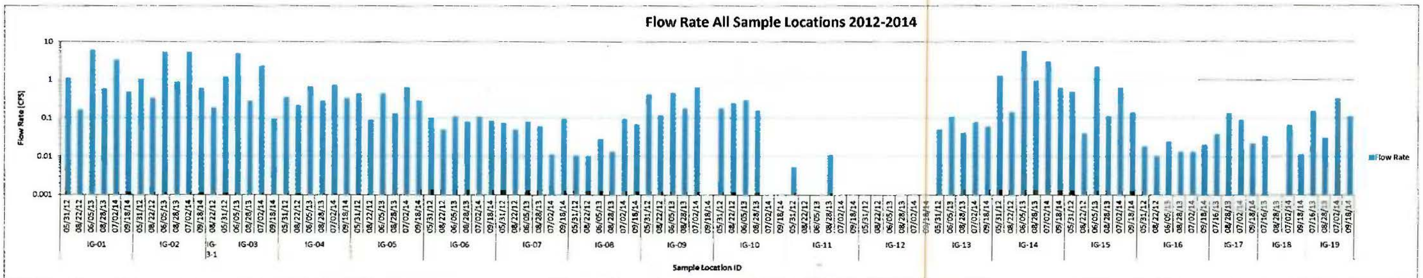
WQCC 2006. Colorado Department of Public Health and Environment, Water Quality Control Commission, 2006, *303(d) List of Impaired Waters*, 2006.

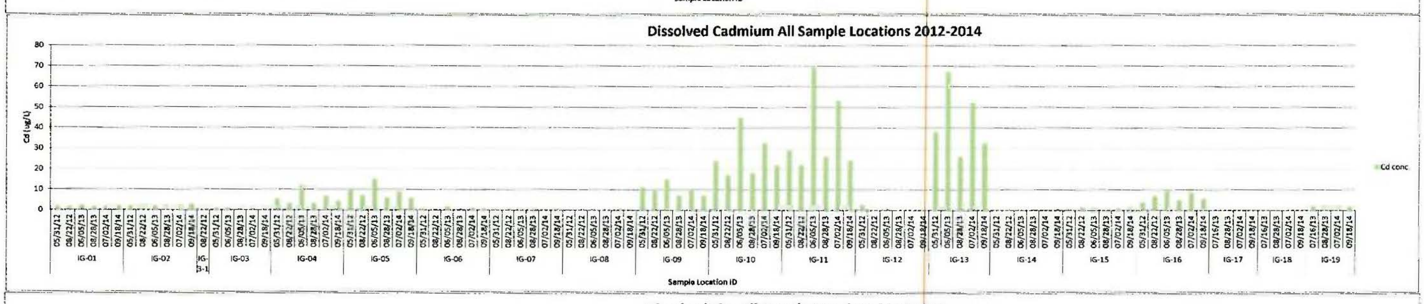
WQCC 2008a. Colorado Department of Public Health and Environment, Water Quality Control Commission, 2006, *Section 303(d) List Water-Quality-Limited Segments Requiring TMDLs. Regulation No. 93.* Effective April 30, 2008.

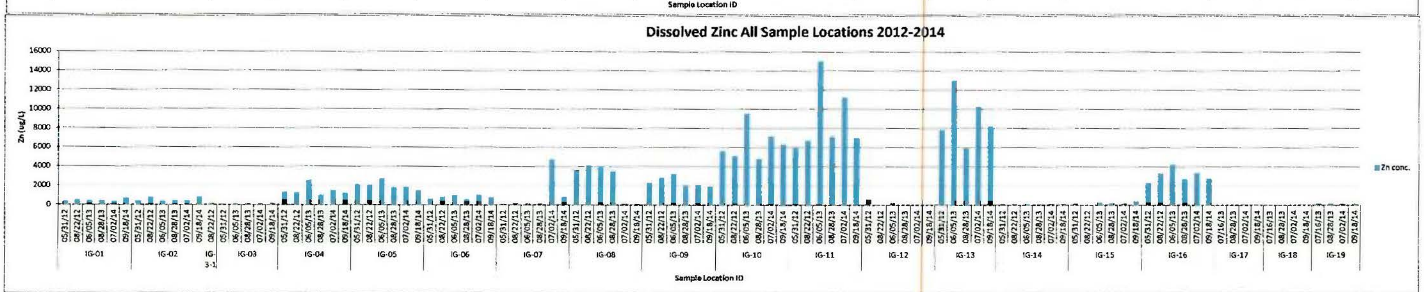
WQCC 2008b. Colorado Department of Public Health and Environment, Water Quality Control Commission, *The Basic Standards and Methodologies for Surface Water, Regulation No. 31.* Effective May 31, 2008.

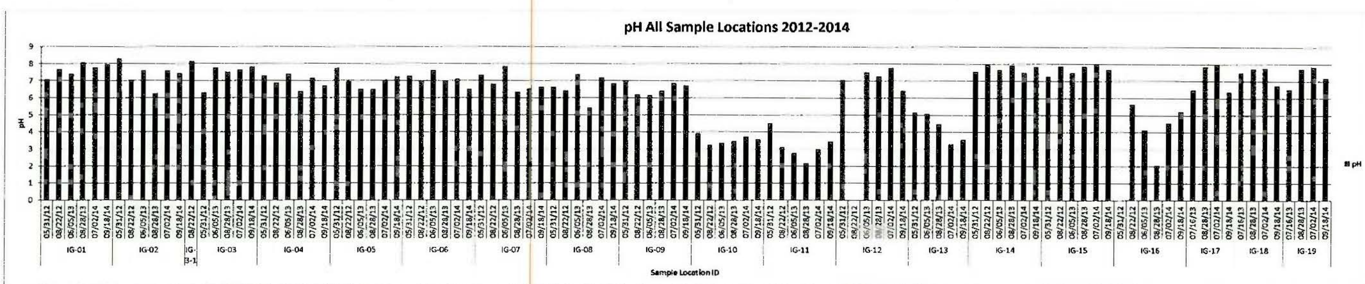
WQCC 2009. Colorado Department of Public Health and Environment, Water Quality Control Commission, *Classification and Numeric Standards for Upper Colorado River Basin and North Platte River (Planning Region 12), Regulation No. 33.* Amended effective January 1, 2009.

Attachment C
Summary Water Quality Bar Charts


Flow Rate All Sample Locations 2012-2014
Flow Rate (CFS)
10
1
0.1
0.01
0.001
Flow Rate
IG-01
IG-02
IG-3-1
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
IG-09
IG-10
IG-11
IG-12
IG-13
IG-14
IG-15
IG-16
IG-17
IG-18
IG-19
Sample Location ID


Dissolved Cadmium All Sample Locations 2012-2014
Cd (ug/L)
80
70
60
50
40
30
20
10
0
Cd conc.
IG-01
IG-02
IG-3-1
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
IG-09
IG-10
IG-11
IG-12
IG-13
IG-14
IG-15
IG-16
IG-17
IG-18
IG-19
Sample Location ID


Dissolved Zinc All Sample Locations 2012-2014
Zn (ug/L)
16000
14000
12000
10000
8000
6000
4000
2000
0
Zn conc.
IG-01
IG-02
IG-3-1
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
IG-09
IG-10
IG-11
IG-12
IG-13
IG-14
IG-15
IG-16
IG-17
IG-18
IG-19
Sample Location ID


pH All Sample Locations 2012-2014
pH
Sample Location ID
IG-01
IG-02
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
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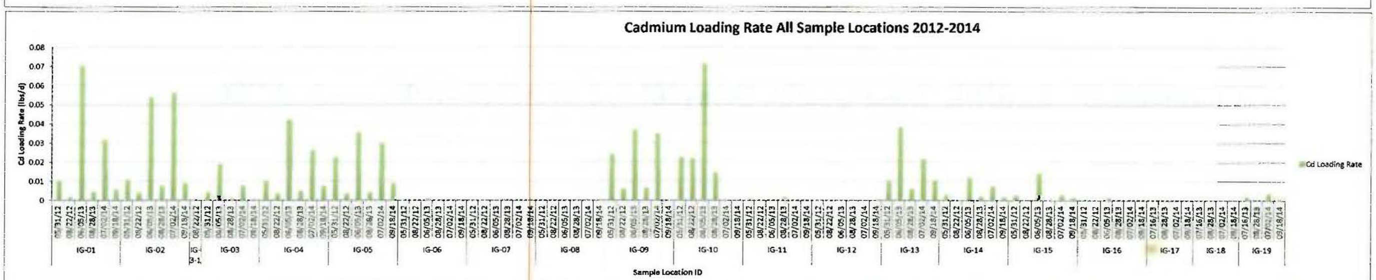
IG-16
IG-17
IG-18
IG-19


Cadmium Loading Rate All Sample Locations 2012-2014
Cd Loading Rate (lbs/d)
Cd Loading Rate
Sample Location ID
IG-01
IG-02
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
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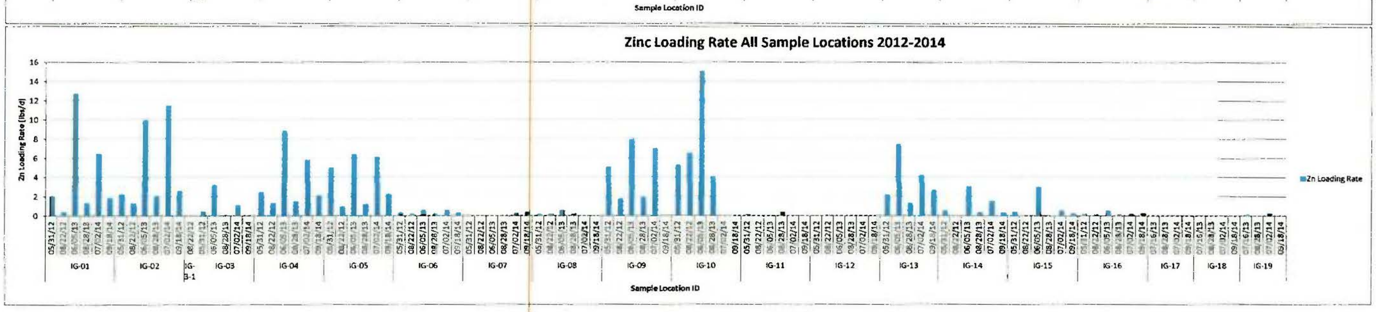
IG-17
IG-18
IG-19


Zinc Loading Rate All Sample Locations 2012-2014
Zn Loading Rate (lbs/d)
Zn Loading Rate
Sample Location ID
IG-01
IG-02
IG-03
IG-04
IG-05
IG-06
IG-07
IG-08
IG-09
IG-10
IG-11
IG-12
IG-13
IG-14
IG-15
IG-16
IG-17
IG-18
IG-19

Attachment D – SCRIBE Water Quality Data (2014) is provided on the attached CD.